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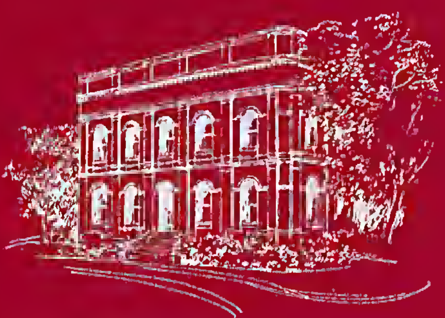

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CONTENTS OF VOLUME 113, NUMBER 2

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PROCEEDINGS

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PEER REVIEWED PAPERS

REWORKED DEVONIAN (GIVETIAN–FRASNIAN) SPORES FROM A PERMIAN GLACIALLY-DERIVED SEQUENCE AT BACCHUS MARSH, VICTORIA

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Pierson, R. R., Foster, C. B. & Archbold, N. W., 2001:12:17. Reworked Devonian (Givetian–Frasnian) spores from a Permian glacially-derived sequence at Bacchus Marsh, Victoria. *Proceedings of the Royal Society of Victoria* 113(2): 207–216. ISSN 0035-9211.

Emphanisporites rotatus McGregor emend. McGregor 1973 is a distinctive Devonian spore with a known primary source age range in Australia spanning the upper Givetian to early Frasnian (Middle to Late Devonian). This is the first record of the species from Victoria. It occurs as a reworked element in an Early Permian assemblage belonging to the *Granulatisporites confluens* Zone derived from glacigene diamictite in the Bacchus Marsh area. As the predominant direction of Permian ice movement recorded in the Bacchus Marsh district was south-west to north-east, it is possible that the reworked spores were transported from Antarctica.

Key words: Palynology, Permian, Devonian, Victorian, diamictite, *Emphanisporites*.

PLANT microfossils act as sedimentary particles in silt sized sediments because of their small size (20–200 μm), abundance, specific gravity, durability and chemical inertness (Playford & Dettmann 1996). They can be reworked into sedimentary rock, transported and redeposited. It is common in non-oxidising palaeo-environments to observe components of older palynomorph assemblages amongst younger, often better preserved palynomorphs, which provide the true age of the sedimentary sequence.

The morphologically distinct Middle to Late Devonian spore *Emphanisporites rotatus* McGregor emend. McGregor 1973 (McGregor 1973) is recorded herein for the first time in Victoria. The reworked specimens (Fig. 1) were recovered from an Early Permian glacigene sequence exposed at the Swing Bridge Section, Lerderderg River, Bacchus Marsh district. This report discusses their significance in relation to local geology and the possibility that they were sourced from Devonian sediments in Antarctica.

LOCALITY DESCRIPTION

Selwyn (1861) was first to recognise the glacigene nature of the sequences that crop out in the Bacchus Marsh area, west of Melbourne. Samples for the present palynological investigation were taken from a diamictite in the glacigene Bacchus Marsh Formation (Roberts 1984) of the Swing Bridge Section (O'Brien 1989; Archbold et al. 1997) at Morven Farm on the eastern bank of the Lerderderg River (Fig. 2). The stratigraphy of the sampled location (Fig. 3) consists of a relatively uniform sequence of poorly bedded, grey colored pebbly diamictite with sandstone lenses and imbricated boulders dipping towards the south. Figure 4 illustrates the diamictite and the sampling location within the Swing Bridge Section.

AGE OF THE GLACIGENE SEQUENCE

Historical evidence

Nineteenth Century discoveries of the fossil plant *Gangamopteris* (McCoy 1875) in the Bacchus Marsh area were, after long-running discussion and debate (see Archbold 1998), progressively assigned to the Permian Period. A Permo-Carboniferous age for the Bacchus Marsh Formation was deduced from the pioneering palynological work in the area by Virkki (1939, 1946). Subsequent authors have also concluded a Late Carboniferous–Early Permian age based upon palynological studies (Pant 1955; Pant & Mehra 1963; Douglas 1969). The marine invertebrate conulariid genus *Notoconularia* was recorded from other localities in the Bacchus Marsh area by Thomas (1969). Garratt (1969) recorded the brachiopod genus *Trigonotreta*, the

bryozoan *Fenestella* and ?*Paraconularia*. Both reports indicated an Early Permian age for the two localities. Arehbold (1991) deseribed the *Trigonotreta* as a new speeies, *Trigonotreta victoriae*, and assigned it to the Early Permian (late Asselian or early Tastubian).

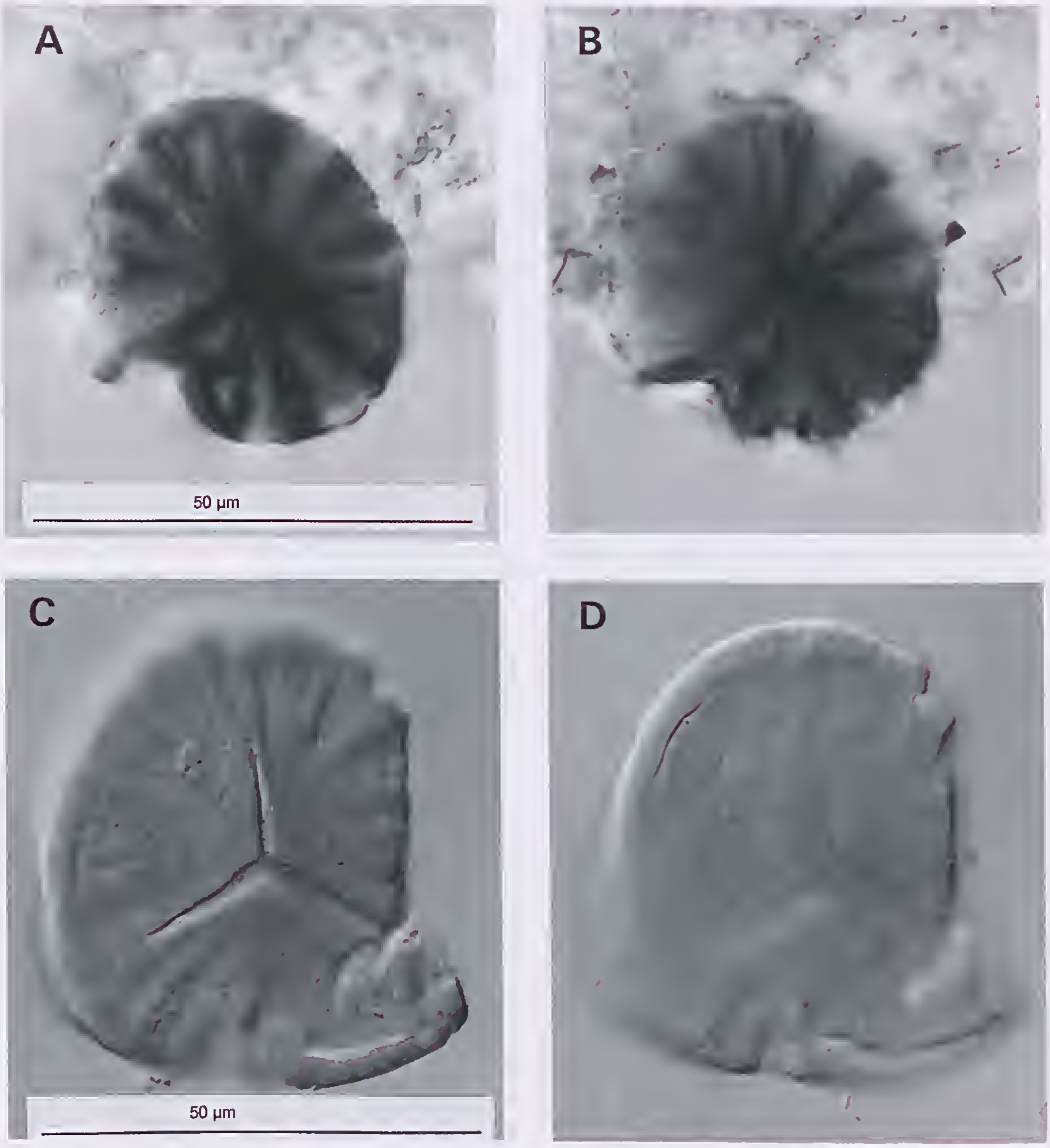


Fig. 1. Reworked *Emphanisporites rotatus* McGregor emend. McGregor 1973 from the Swing Bridge Section. A, proximal view; B, distal view (CPC36662). C, proximal view; D, distal view (CPC36664). *Note:* All palynomorphs in Figs 1, 5 and 6 were photographed using Differential Interference Contrast optics on an Olympus BX50 microscope system, No. 8L08051, housed at Deakin University. Illustrated palynomorphs are lodged with the Commonwealth Palaeontological Collection (CPC), housed at Geoscience Australia, Canberra. Reference numbers, prefixed CPC, are for that collection.

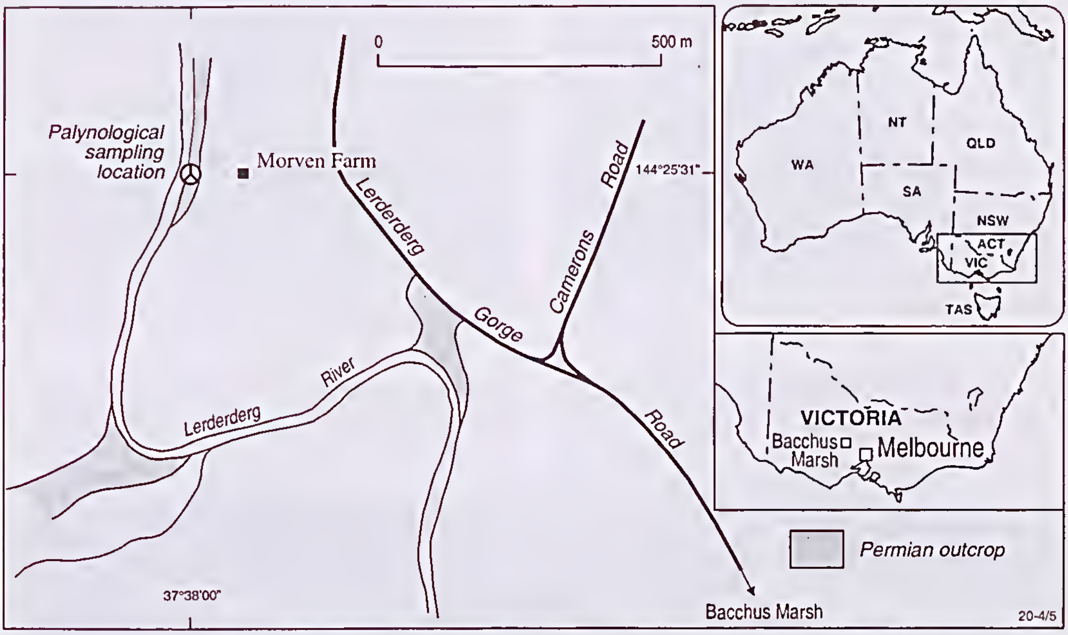


Fig. 2. Geological map of the Early Permian Bacchus Marsh Formation diamictite, Lerderderg River, Swing Bridge Section.

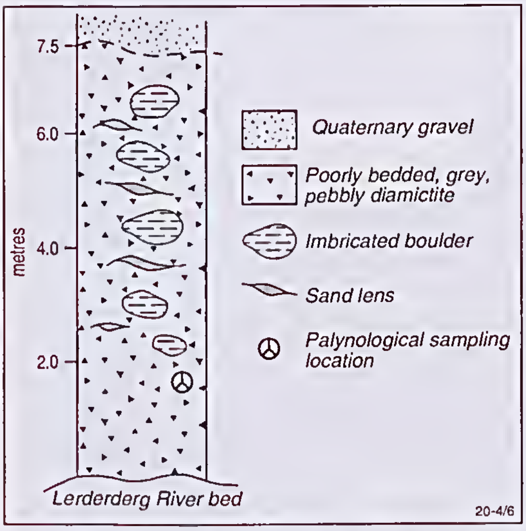


Fig. 3. Stratigraphical column at the Swing Bridge Section sampling location.

New palynological evidence

The present study has confirmed an Early Permian (Sakmarian) age for the diamictite sample from the Swing Bridge Section. The Swing Bridge Section assemblage belongs to the *Granulatisporites confluens* Oppel-zone of Foster & Waterhouse (1988). This widespread Gondwanan Oppel-zone is particularly indicative of the Tastubian substage throughout Gondwana (Archbold 2001). Taxa that are diagnostic of the *Granulatisporites confluens* Oppel-zone include *Microbaculispora tentula*, *Granulatisporites confluens*, *Caheniasaccites* sp. and *Horriditriletes ramosus* (Fig. 5), and *Plicatipollenites gondwanensis*, *Cycadopites follicularis* and *Protohaploxypinus* sp. (Fig. 6). Only key Permian taxa are described herein. A more complete record of the total Permian palynomorph assemblage at Bacchus Marsh will be discussed elsewhere.

The reworked Devonian elements are very rare in the assemblage, <0.5%, with only one species, *E. rotatus*, being identified. No other Devonian species were recognised with certainty.

DISTRIBUTION OF *EMPHANISPORITES ROTATUS*

McGregor & Playford (1992) have provided a comprehensive overview of the distribution of *Emphanisporites rotatus* in Australia. It is confined to sediments of Givetian–Frasnian age (late-Middle to early-Late Devonian). The species has been

found in the following lithostratigraphical units: Gneudna Formation, Carnarvon Basin, Western Australia; Parke Siltstone, Amadeus Basin, Northern Territory; Gogo Formation and Pillara Limestone, Canning Basin, Western Australia; and the carbonaceous siltstone of the Eugenana beds, north-eastern Tasmania. In addition to McGregor & Playford's distribution, a single specimen, 'most closely comparable with *Emphanisporites rotatus*', from the Upper Etonvale Formation of the Adavale Basin, Queensland, was figured by de Jersey (1966).

Significantly *Emphanisporites rotatus* has not previously been recorded from Victoria. This raises the question of provenance of the specimens found at Bacchus Marsh.

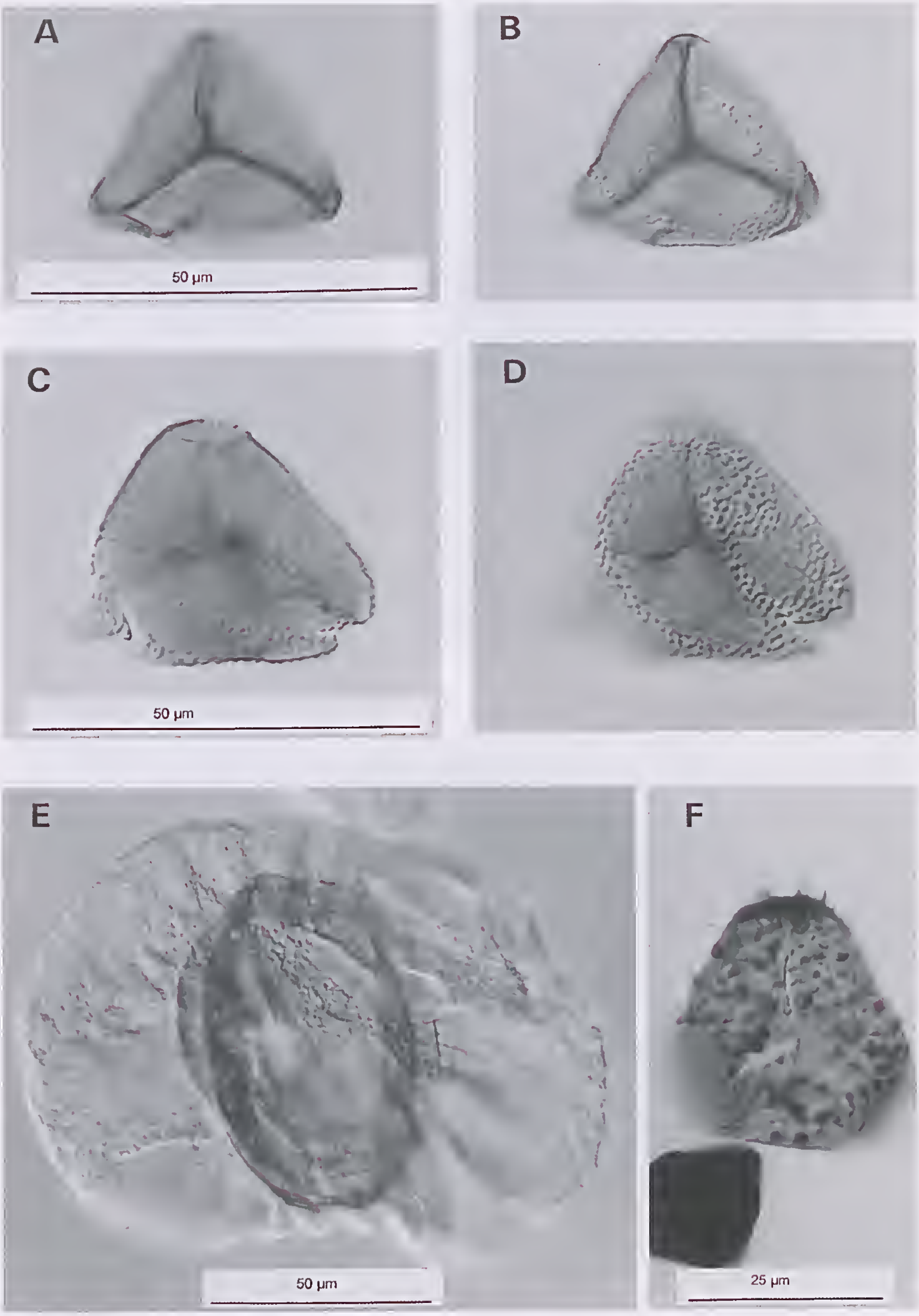
PROVENANCE OF BACCHUS MARSH DEVONIAN SPORES

Ice movement during the Early Permian of south-east Australia

During the Early Permian, ice covered much of Victoria and western and north-eastern Tasmania (Brakel 1990). In the vicinity of Bacchus Marsh, ice flowed 'northward between 20° and 30°' (Crowell & Frakes 1971a). Crowell & Frakes (1971b) observed evidence of ice flow direction at the Morven Farm (Swing Bridge) Section as approximately N40°E. In the same section, Bowen & Thomas (1976) reported striations in bedrock at approximately N50°E. Brakel & Totterdell (1992)

Fig. 4. Diamictite exposed on the eastern bank of the Lerderderg River, revealing imbricated boulders and dip to the southwards.

Fig. 5. Specimens from the *Granulatisporites confluens* Oppel-zone of the Swing Bridge Section. A, B, *Microbaculispora tentula* Tiwari 1965: A, proximal view; B, distal view (CPC36656). C, D, *Granulatisporites confluens* Archangelsky & Gammerro 1979: C, proximal view; D, distal view (CPC36657). E, *Caheniasaccites* sp. (CPC36660). F, *Horriditriletes ramosus* (Balme & Hennelly) Bharadwaj & Salujha 1964 (CPC36658).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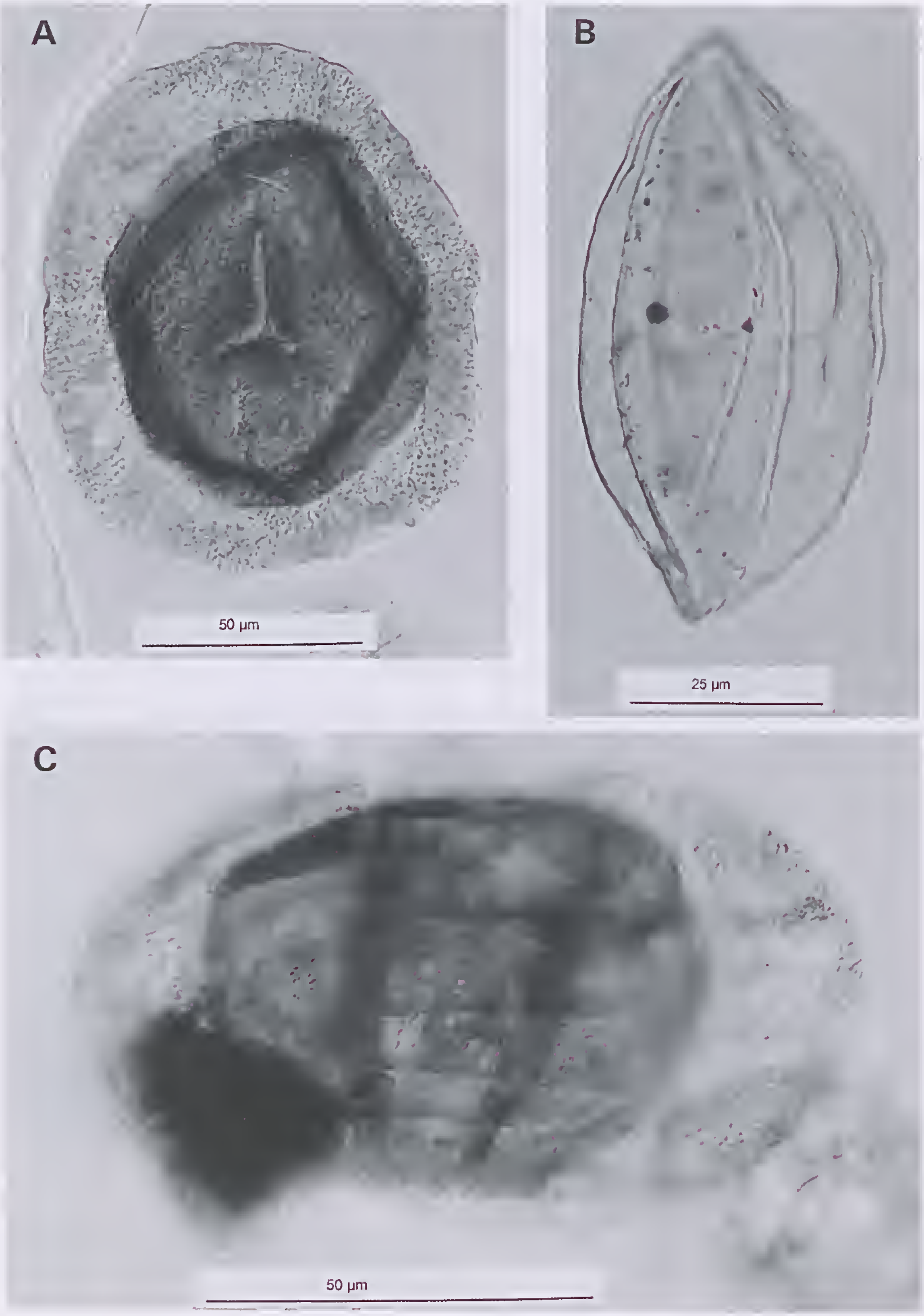
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deduced that, 'all ice directions are northerly; ... ice encroaching into Tasmania, Victoria, and South Australia radiated out from a centre in northern Victoria Land in adjacent Antarctica'.

The above records of direction of ice movement in the vicinity of Bacchus Marsh and at the Swing Bridge Section include a range of values. The evidence indicates that ice movement was from the south-west to the north-east at this locality. This ice would have transported the appropriate Devonian aged rocks containing the reworked spores.

Victorian Givetian–Frasnian sedimentary rocks

Marsden (1976) stated that during the Middle and Late Devonian, 'only very minor sedimentation occurred in the Central Victorian Province', which includes the Bacchus Marsh area. Approximately 100 km to the north-east of Bacchus Marsh, the Mount Howitt Province contains extensive Late Devonian (Late Givetian to Famennian) sediments (Marsden1976).

All Devonian sedimentary rocks of appropriate age in Victoria are north and east of the Bacchus Marsh locality, while the Permian ice flow was from south-west to north-east. The possibility that Devonian spores, originating from appropriately aged rocks from within Victoria, were transported to Bacchus Marsh by ice movement, appears highly unlikely.

The evidence presented here suggests a non-local origin for the reworked spores. This contrasts with the conclusion reached by Harris & McGowran (1971) who also reported recycled Devonian palynomorphs from diamictites of the same age from the Cape Jervis Beds, Troubridge Basin, South Australia (see also Gilby & Foster 1988; Foster 1974). Harris & McGowran's conclusion of a local origin for the Devonian spores was based upon the preservation of the recycled forms, including rare specimens of *Ancyrospora* sp. This taxon was not observed during the present study.

Southern sources of Devonian rocks

Banks & Burns (1962) assigned spores to the genus *Radiaspora*, now regarded as congeneric with *Emphanisporites* (Balme 1964; McGregor 1973), from Upper Middle Devonian cave deposits at Eugenana, north-eastern Tasmania.

In Antarctica, *Emphanisporites* has been observed in Devonian assemblages from south Victoria Land, Beacon Valley, Aztec Siltstone (Helby & McElroy 1969) and Terra Cotta Siltstone (Kyle 1977), as well as from the Transantarctic Mountains, Ohio Range, Horlick Formation (Kemp 1972).

An Early Permian (Sakmarian) palaeogeographical reconstruction of Antarctica and Australia (Fig. 7), supports our suggestion that *Emphanisporites* spores found at Bacchus Marsh were sourced from the Devonian successions within the Transantarctic Mountains of Antarctica. During the Early Permian, ice movement could have transported the rock in a north-easterly direction to deposit the spores in diamictite at Bacchus Marsh. A less likely source for the reworked spores may have been north-eastern Tasmania.

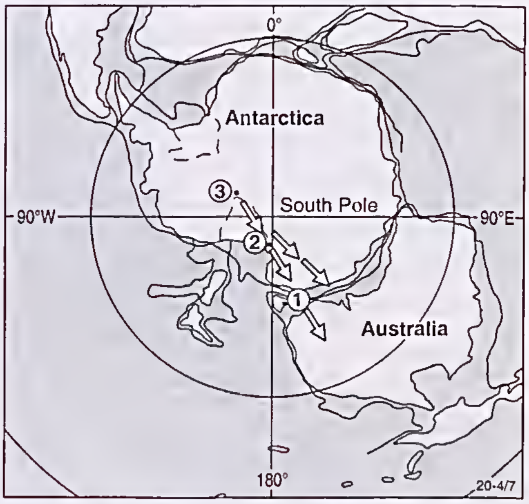

Fig. 7. Early Permian (Sakmarian) palaeogeographical reconstruction showing locations of possible palynomorph-bearing Devonian source rock in Tasmania and Antarctica and the path of ice transportation to south-eastern Australia. 1, north-eastern Tasmania (Eugenana beds); 2, south Victoria Land (Aztec Siltstone and Terra Cotta Siltstone); 3, Transantarctic Mountains, Ohio Range (Horlick Formation). Reconstruction after Truswell (1991).

Fig. 6. Specimens from the *Granulatisporites confluens* Oppel-zone of the Swing Bridge Section. A, *Plicatipollenites gondwanensis* (Balme & Hennelly) Lele 1964 (CPC36663). B, *Cycadopites follicularis* Wilson & Webster 1964 (CPC36659). C, *Protohaploxypinus* sp. (CPC36661).

CONCLUSION

This record of *Emphanisporites rotatus* from the Early Permian Bacchus Marsh Formation at the Swing Bridge Section represents the first report of the late-Middle to early-Late Devonian species in Victoria. Evidence of Early Permian southerly to northerly ice movement from Antarctica to southern Australia strongly suggests an Antarctic source for this reworked species at Bacchus Marsh.

ACKNOWLEDGEMENTS

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APPENDIX

Systematic palaeontology

Genus *Emphanisporites* McGregor 1961

Type species (by original designation). *Emphanisporites rotatus* McGregor 1961.

Emphanisporites rotatus McGregor emend. McGregor 1973: fig. 1A–D.

Partial synonymy (see McGregor 1973: 46–47 for complete listing).

1960 *Radiaspora* sp. A.—Balme: p. 6, pl. 1, figs 11, 12.
1961 *Emphanisporites rotatus* McGregor: p. 3, pl. 1, figs 1–4.
?1962 '*Radiaspora*'—Banks & Burns: (no figs and no description).
1964 *Radiaspora* sp.—Balme: pl. 1, fig. 1. (no description).
1966 *Emphanisporites* sp.—de Jersey: p. 14, pl. 6, fig. 3.
1969 *Emphanisporites* sp.—Helby & McElroy: fig. 3D (no description).
1971 *Emphanisporites* sp. cf. *E. rotatus*—Harris & McGowran: fig. 1 (no description).
1972 *Emphanisporites rotatus*—Kemp: pl. 55, figs 1–3 (no description).
1973 *Emphanisporites rotatus*—McGregor emend.: p. 47, pl. 6, figs 9–13.
?1977 *Emphanisporites* spp.—Kyle: (no figs and no description).

Description (from McGregor 1973: 47)

'Trilete miospores, amb broadly subtriangular to circular. Sutures simple or with low, narrow labra, extend to or nearly to equator. Distal hemisphere unsculptured; proximal face with 4 to 10 radial, spoke like ridges in each interradial sector. Ridges widest towards the equator, narrowing proximally and commonly fused to form a thick, slightly darker zone around the proximal pole. On some specimens there may be little or no merging of the ridges at the pole, and on some the ribs may extend only part way towards the pole, the apex of the spore being devoid of ridges or other sculpture. Ridges may bifurcate or trifurcate towards the equator. Laesurae commonly flanked by ridges. Wall about 1.5–3 μm thick distally, and on some specimens 1–2 μm thicker (cingulate) in a narrow zone at the equatorial region of the distal hemisphere.

Curvaturae have been detected on some specimens, but they usually are not evident because the rays are long, and the spore rarely is compressed laterally. Diameter 32–84 μm, mean 54 μm.'

Remarks

The two figured specimens conform to the range within the above diagnosis for *E. rotatus*. Their diameters are 54 μm and 42 μm.

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NEW STROPHALOSIIDAE (BRACHIOPODA) FROM THE EARLY PERMIAN OF ARGENTINA

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[2]Museo de La Plata, CONICET, Paseo del Bosque s/n, 1900 La Plata, Argentina

Archbold, N. W. & Simanauskas, T., 2001:12:17. New Strophalosiidae (Brachiopoda) from the Early Permian of Argentina. *Proceedings of the Royal Society of Victoria* 113(2): 217–227. ISSN 0035-9211.

New representatives of the family Strophalosiidae (Brachiopoda) are described from the Tupe Formation of the Paganzo Basin, Argentina. The genus *Coronalosia* Waterhouse & Gupta is reviewed and the new taxa *Coronalosia argentinensis* sp. nov. and *Tupelosia paganzoensis* gen. et sp. nov. proposed. The age of the Tupe Formation is reviewed and a middle to late Asselian (Early Permian) age is preferred.

The new genus *Guadalupelosia* from the mid-Permian of West Texas, USA, is also proposed.

Key words: Permian, Argentina, Brachiopoda, Strophalosiidae, Paganzo Basin, West Texas, new taxa.

STROPHALOSIID brachiopods (Family Strophalosiidae) are a significant component of many Permian marine benthonic communities. The family underwent significant evolutionary expansion in areas of cold and temperate marine waters during the Permian (Waterhouse 1967). Strophalosiids, frequently of large size, were abundant throughout the Permian of Gondwana as indicated by the following regions and representative studies: New Zealand (Waterhouse 1964, 1982), eastern Australia (Briggs 1998; Waterhouse 1986), Western Australia (Archbold 1986, 1987, 1993), Irian Jaya (Archbold 1992), Tibet and the Himalaya (Zhang & Ching 1976; Waterhouse 1978; Waterhouse & Gupta 1978), Peninsular India (Archbold et al. 1996), the Salt Range, Pakistan (Waagen 1883) and Oman (Angiolini et al. 1997). Etheridge (1872) was the first to illustrate strophalosiids from the Permian of Gondwana when describing Sir Richard Daintree's Queensland palaeontological collections.

Strophalosiid brachiopods are also well developed in the younger Permian deposits of northeastern Siberia including the Kolyma region (Tolmachev 1912; Likharev 1932, 1934; Tsaregradskii 1945; Zavodovskiy 1960; Zavodovskiy & Stepanov 1971), the Verkhoyansk Mountains, including the Kharaulakh Range in the north (Fredericks 1931; Kashirtsev 1955, 1959; Abramov & Grigor'eva 1988; Solomina 1988), the Taimyr Peninsula (Ustritskiy & Chernyak 1963) and the Canadian Arctic (Waterhouse 1969). Somewhat rarer and often smaller forms are known from Novaya Zemlya (Kalashnikov & Ustritskiy 1981) the Kanin Peninsula, the northern Urals and the Pay Khoy (Kalashnikov 1993) perhaps reflecting warmer (temperate) marine temperatures. The same applies to transitional (temperate) faunas of the Russian Far East (Fredericks 1925) and north-east China (Lee et al. 1980). Strophalosiids are also smaller and rarer in peripheral Gondwanan regions (eg. Oman, the Salt Range and Peninsular Thailand) also reflecting somewhat warmer water temperatures (Angiolini et al. 1997; Waagen 1883; Grant 1976).

Tropical and subtropical Permian seas were characterised by small, usually rare strophalosiids as in regions such as the Zechstein Basin of Europe (Geinitz 1848) and the Glass Mountains of Texas (Cooper & Grant 1975). The family is apparently absent from the tropical faunas of South China.

SOUTH AMERICAN PERMIAN STROPHALOSIIDAE

The South American Permian marine faunas have yielded few strophalosiids. The family is absent in the classic Early Permian faunas of Bolivia and Peru (Kozlowski 1914; Branisa 1965; Newell et al. 1949) and has not been recorded from the mid-Permian of Venezuela (Hoover 1981). From Argentina, Antelo (1972; see also Amos 1979) described and figured a strophalosiid species from the Quebrada Larga, in the upper valley of the Rio Blanco, San Juan Province. He referred his specimens to the species *Strophalosia cornelliana*

Derby (1872), a species placed in *Heteralosia* King (1938) by Mendes (1959, 1961) and Antelo (1972), that was originally described from the Upper Carboniferous (Pennsylvanian) Itaituba Series, Amazon Basin, Brazil. As discussed below, Antelo's material is not closely related to Derby's species but is closely allied to *Coronalosia argentinensis* sp. nov. Antelo's (1972) described fauna shares species with the fauna of the Tupe Formation (Paganzo Basin) which has yielded the species described herein. This argues for a correlation of the two faunas (Simanauskas & Cisterna 2000a).

New records from Argentina

Stratigraphy and location. All specimens described herein come from outcrops of the Tupe Formation at La Herradura Creek, located on the western flank of Perico Hill, about 20 km northeast of Jachal, San Juan Province, Argentina (Fig. 1). This region belongs to the preordilleran or western sector of the Paganzo Basin (Guandacol Embayment). The Tupe Formation at this locality represents a brief but widely extended marine transgression from the Panthalassic Ocean into the western Paganzo Basin (Lopez Gamundi et al. 1994).

The brachiopods documented herein come from a 40 m thick marine interval in the upper part of the Tupe Formation, the lithologies of which consists of alternating sandstones, claystone and calcareous beds. The marine interval represents a short-lived marine transgression within a deltaic system with swamps and hence a high proportion of organic matter (Ottone & Azcuy 1986). All the strophalosiid specimens figured and described herein, come from an horizon approximately 25 m above the base of the marine interval (Fig. 2).

Previous studies and age. The stratigraphical section of the Tupe Formation at La Herradura Creek is considered to be the stratotype of the *Tivertonia jachalensis–Streptorhynchus inaequiornatus* Biozone (Sabattini et al. 1990). However, the brachiopod fauna of the Tupe Formation has been poorly understood in modern terms. Leanza (1945) described and illustrated several brachiopod species with the names *Chonetes scitula* Leanza, *Streptorhynchus inaequiornatus* Leanza, *Spirifer (Spirifer) pericoensis* Leanza and *Syringothyris keideli* Harrington. *Chonetes scitula* Leanza was later found to be a preoccupied name (Amos 1961) and was renamed as *Lissochonetes jachalensis* Amos. Simanauskas (1991) revised the species and included material from La Herradura Creek in his review.

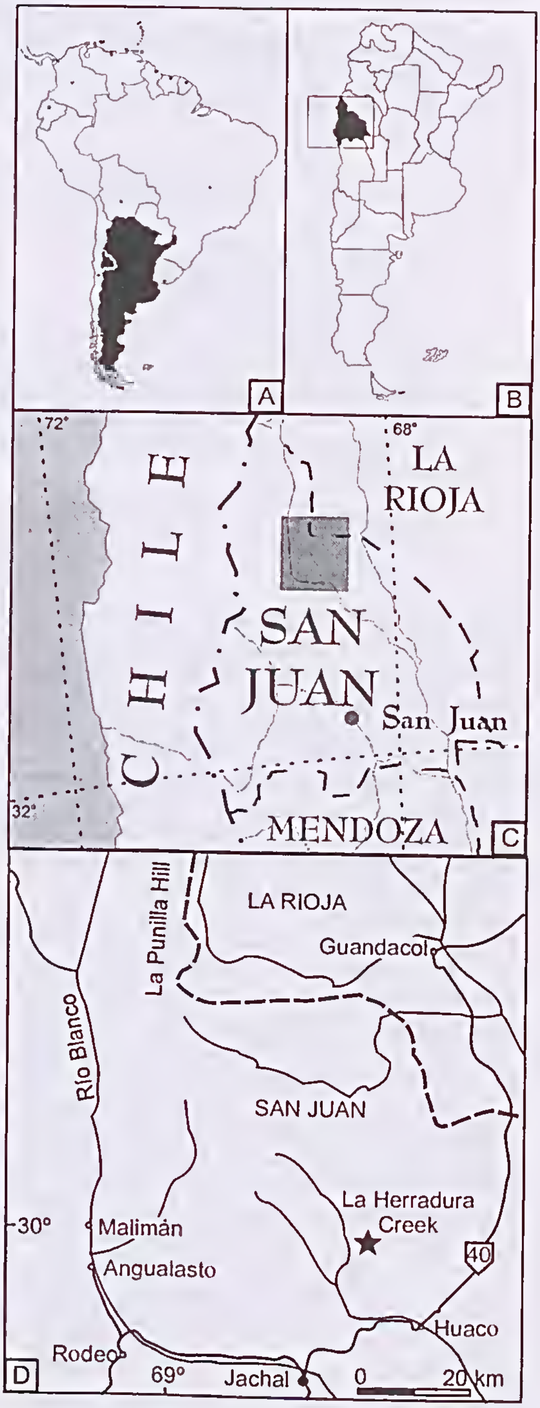


Fig. 1. Location maps showing: A, South America; B, Argentina; C, San Juan Province; D, the Tupe Formation locality.

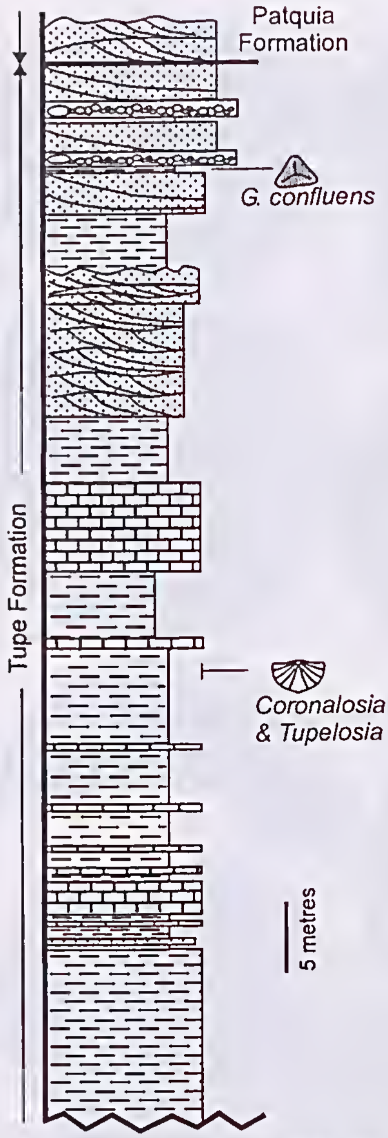


Fig. 2. Stratigraphical log of the upper part of the Tupe Formation, La Herradura Creek.

The *Tivertonia jachalensis–Streptorhynchus inaequiornatus* Biozone was previously known as the 'fauna intermedia' of Gonzalez (1985) and the 'Zona de Intervalo' of Archangelsky et al. (1987) who regarded the zone as being of Late Carboniferous age. More recent studies, which compare correlated Argentine faunas closely with other Gondwanan faunas and associated palynological data, point to an Early Permian (mid to late Asselian) age for the Zone (Cisterna & Simanauskas 2000; Simanauskas & Cisterna 2000b). These studies are consistent with Australian studies (eg. Archbold & Hogeboom 2000) that treat the first appearance datum of the spore *Granulatisporites confluens* as being of latest Asselian age. The Tupe Formation marine fauna occurs immediately below this key palynological zone and hence is regarded as being mid to late Asselian in age.

Collections. All figured specimens are housed in the collections of the Departimento Cientifico de Geologia, Museo de La Plata, with the registration prefix DCG-MLP. All figure specimens of new species, other than holotypes, are paratypes. Additional, fragmentary specimens of both new Argentinian species described herein were also examined.

SYSTEMATIC PALAEONTOLOGY

Order PRODUCTIDA Sarycheva & Sokolskaya, 1959

Suborder STROPHALOSIIDINA Waterhouse, 1975

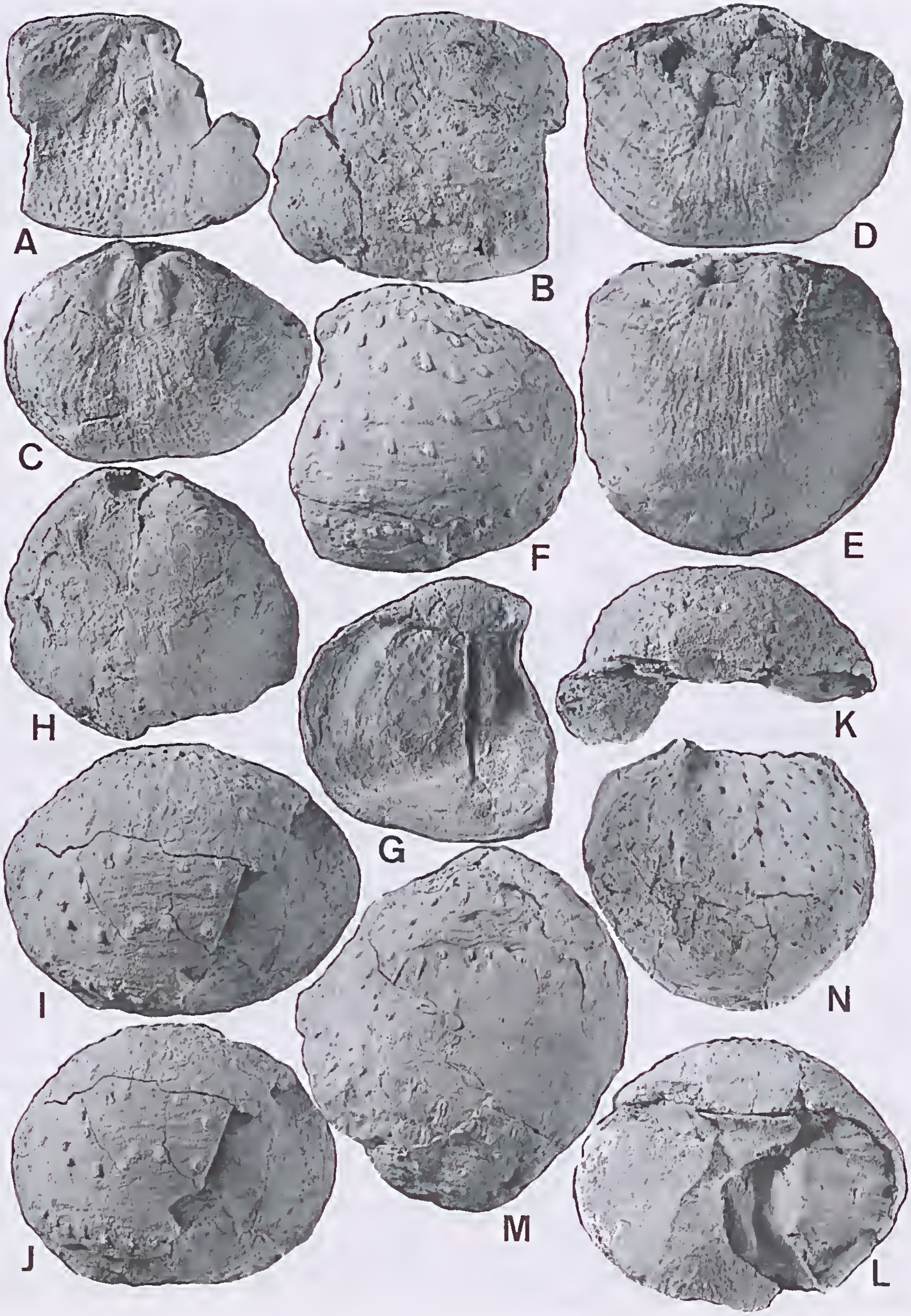
Discussion. Waterhouse (2001: 52–54) has comprehensively reviewed the use of the subordinal name Strophalosiidina. The present author ascribes the first usage of the subordinal name to Waterhouse as he was the first proposer of the subordinal rank of the group. At the very least, the date 1978 should be given for the proposal, in view of the full discussion of the subordinal content provided at that time, although the name was first published in 1975. The date 1975 has always been applied to the suborder by Archbold in his previous studies of the group (eg. Archbold 1986, 1987). As noted by Waterhouse (2001), the Brunton et al. (2000) content of the suborder is, in fact, the same as that recognised by Waterhouse (1978).

Superfamily STROPHALOSIOIDEA Schuchert, 1913

Family STROPHALOSIDAE Schuchert, 1913

Subfamily STROPHALOSIINAE Schuchert, 1913

Discussion. Brunton et al. (2000) recognised three subfamilies within the Strophalosidae Schuchert, primarily based on the distribution of body spines.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The Strophalosiinae Schuchert were defined by only having spines on the ventral valve, the Dasyalosiinae Brunton by having spines on both valves and the Mingenewiinae Archbold by having no spines. The value of subdividing the family as proposed by Brunton et al. (2000) is not followed here because the presence or absence of dorsal spines is unlikely to be a feature of subfamilial importance although useful at the generic level (Waterhouse 1964, 1969; Clarke 1970; Archbold 1986; Briggs 1998). The Dasyalosiinae Brunton is restricted to those forms with relatively coarse, intertwining spines as suggested by Briggs (1998: 65).

Genus **Coronalosia** Waterhouse & Gupta, 1978

Type species. Coronalosia blijniensis Waterhouse & Gupta, 1978.

Diagnosis. Ventral valve with relatively coarse, widely spaced body spines. Dorsal valve smooth with poorly developed pits or dimples and only rarely with radial capillae. Interior of ventral valve with striae at maturity.

Discussion. The generic name *Archaelosia* Waterhouse & Gupta (1977: 14, 1983: 125) is a *nomen nudum* which apparently refers to *Coronalosia*, a genus validly described in 1978. *Coronalosia* was accepted as a valid genus by Archbold & Singh (1993) and Brunton et al. (2000). Waterhouse (2001: 54–55, pl. 4, figs 17–21) has done much to clarify the genus and its type species. For the present study, the examination of a large suite of specimens of the type species from the Dugadda area, Garwhal Lesser Himalaya, collected by Prof. John Talent of Macquarie University, has been essential in clarifying details of the genus. *Coronalosia* is morphologically closest to *Strophalosia* King (1844), type species *Strophalosia gerardi* King (1846), but is distinguished from that genus by means of its relatively coarse, widely spaced ventral spines; essentially smooth dorsal valve exterior often with no pits or pustules and rarely with radial capillae. The ventral diductor scars of *Coronalosia* are patterned with radial striae at maturity and the radial striae continue in front of the muscle scars at maturity. The valves are thickened in gerontic individuals of *Coronalosia*.

Coronalosia argentinensis sp. nov.

Figs 3A–N, 4A–F

Holotype. DCG-MLP 356c, a mature dorsal valve.

Figured material. Three dorsal valves—DCG-MLP 356c, 356g, 356h; three ventral valves—DCG-MLP 356a, 356d, 356l; three ventral valve internal moulds—DCG-MLP 356i, 356j, 356k; one incomplete conjoined shell—DCG-MLP 356b; one ventral valve external mould—DCG-MLP 356m.

Size ranges. Maximum width, 17.5–27 mm; hinge width, 7.7–13.2 mm; ventral valve length, 13–24.5 mm; dorsal valve length, 14–17.5 mm; shell thickness, 5–9.5 mm.

Diagnosis. Small to medium sized *Coronalosia* with strongly convex ventral valve; widely spaced, subquincuncially arranged coarse ventral spines; strongly impressed adductor scars; low, thick bilobed cardinal process and thickened dorsal median septum at maturity.

Description. Shell small to medium sized for genus, transversely oval or subcircular in outline. Hinge width about two-thirds of maximum width. Convexity of ventral valve strongly developed and relatively even. No ventral sulcus but slight median flattening present. Umbo low, cicatrix often distinct. Dorsal valve gently concave. Ventral interarea low, delthyrium apparently small. Dorsal interarea low, poorly known.

Ornamentation of ventral valve consists of scattered, relatively coarse spines in subquincuncial pattern, one series only projecting at low angle, up to 1.2 mm thick at base spaced at 2 to 3 mm at 15 mm from umbo. Ears virtually absent. Growth lines weakly developed, somewhat irregular. Dorsal valve with no spines, dimples and capillae apparently absent.

Ventral interior with small teeth; adductor scars distinct, smooth, bisected by low ridge. Diductor scars large, flabellate, gently striated. Much of valve floor irregularly striate.

Fig. 3. Coronalosia argentinensis sp. nov. A, B, DCG-MLP 356d, incomplete ventral valve, internal and external views, × 3, × 3.5. C, DCG-MLP 356i, ventral valve internal mould in postero-ventral view, × 2.5. D, E, DCG-MLP 356j, ventral valve internal mould in posterior and ventral views, × 3. F, G, DCG-MLP 356b, conjoined shell in ventral and dorsal views, × 2.6, × 2.2. H, DCG-MLP 356k, ventral valve internal mould in ventral view, × 3.5. I–L, DCG-MLP 356a, ventral valve in ventral, antero-ventral, posterior and postero-dorsal views, all × 3.5. M, DCG-MLP 356l, incomplete ventral valve in ventral view, × 2.5. N, DCG-MLP 356m, ventral valve external mould, × 3.

Dorsal valve interior with strong median septum and stout, thickened bilobed cardinal process. Septum about half valve length. Adductor scars, smooth. Brachial ridges well developed.

Discussion. The new species is smaller and more strongly ventrally convex than *Coronalosia blijniensis* Waterhouse & Gupta (1978). *Strophalosia irwinensis* Coleman (see Archbold 1986: figs 1A–Z) is allied to *Coronalosia* as indicated by Briggs (1998: 66–67) and Waterhouse (2001) but is a somewhat larger species with a more gentle ventral valve convexity. Ventral spine pattern of the Western Australian, Sterlitamakian species is similar to that of *Coronalosia argentinensis*. The early Artinskian, Western Australian *Strophalosia jimbaensis* Archbold (1986; see also Archbold & Shi 1993) is also allied but is a large species with distinct dorsal dimples.

Antelo (1972: 164–167, pl. 2, figs 1–5) described specimens of a strophalosiid from Quebrada Larga, Rio Blanco, San Juan which he referred to *Heteralosia cornelliana* Derby (1872: 45–46, pl. 3, figs 28, 30, 32, 35–38; pl. 4, fig. 5; pl. 8, fig. 17; pl. 9, figs 10–11; see also reproductions of Derby's plates of brachiopods in Gonsalves 1952). Mendes (1959: 75–78, pl. 7, figs 4a–b, 5; 1961: 16, figs 19–20), transferred Derby's species from *Strophalosia* to *Heteralosia* King (1938). True *H. cornelliana* is a small species that is referable to *Heteralosia sensu stricto* or a closely related genus. The Brazilian species is comparable with small species of that genus described from the Permian of Texas (Cooper & Grant 1975). Derby's species is from the Upper Carboniferous (Pennsylvanian) Itaituba Series of the Amazon Basin, Brazil. The specimens described by Antelo (1972) are much larger than Derby's species and comparison is indicated with *Coronalosia* in view of their transversely oval outline. Illustrations of the ventral spine patterns and the dorsal valve exterior are not provided by Antelo (1972) but the dorsal valve is described by Antelo as lacking spines. Amos (1979: 75, figs a and b) refigured two of Antelo's specimens and confirmed the low nature of the cardinal process of a submature dorsal valve. Specimens collected by Dr Gabriela Cisterna and Dr Mauricio Martinez from the same locality as Antelo's material reveal ventral spines that are widely spaced, but finer than those of our species, and rare capillae on the dorsal valve but no dorsal spines. Dimples are also present on the dorsal exterior.

Genus **Tupelosia** nov. Simanauskas & Archbold

Type species. Tupelosia paganzoensis sp. nov. Simanauskas & Archbold.

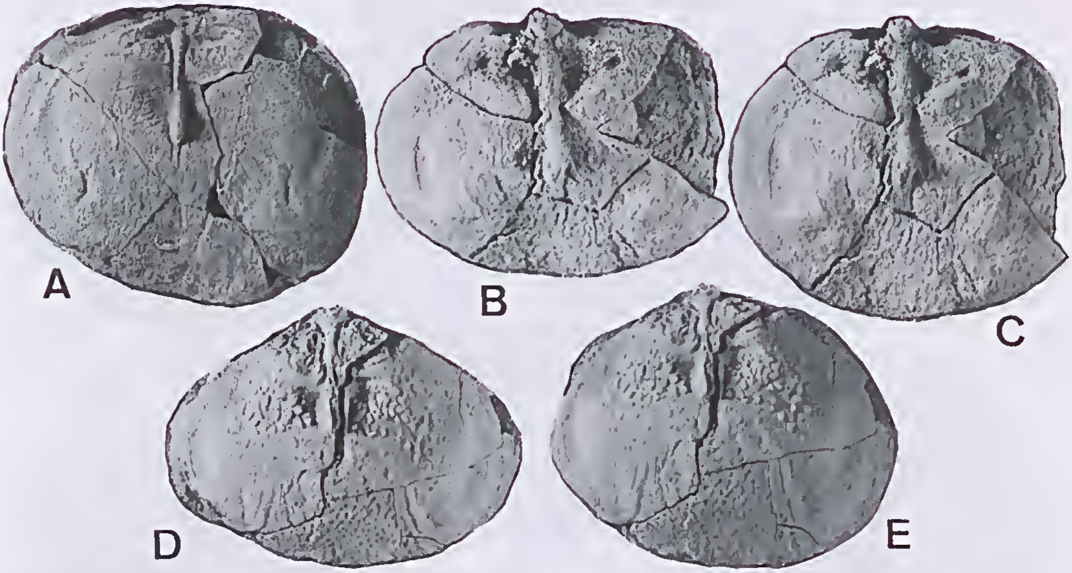

Fig. 4. Coronalosia argentinensis sp. nov. A, DCG-MLP 356g, dorsal valve, internal view, ×2.6. B, C, holotype, DCG-MLP 356c, dorsal valve interior in tilted and normal views, ×3. D, E, DCG-MLP 356h, dorsal valve interior in tilted and normal views, ×3.

Diagnosis. Circular to slightly elongate Strophalosiinae with coarse recumbent ventral spines; squat, blunt internally bilobate cardinal process; dorsal septum short, about 0.3 of valve length. Ventral adductor scars deeply impressed, strongly elongate. Dorsal exterior smooth, spines absent, dimples and capillae absent. Valves strongly thickened.

Discussion. *Tupelosia* gen. nov. is readily differentiated from all other Strophalosiinae by its distinctive shell outline, ventral spine pattern, ventral adductor muscle scars, dorsal cardinal process and median septum. The thickened shell of *Tupelosia* at maturity recalls the shell thickening of *Coronalosia* but other morphological features such as the details of the ventral diductor scars, dorsal median septum and cardinal process are distinctive.

Tupelosia paganzoensis sp. nov. Simanauskas & Archbold

Fig. 5A–M

Holotype. DCG-MLP 356f, a complete mature dorsal valve.

Figured material. Two dorsal valves—DCG-MLP 356f, 356n; three ventral valves—DCG-MLP 356e, 356o, 356p.

Size ranges. Maximum width, 17–18 mm; hinge width, 9–10.5 mm; dorsal valve width, 17–17.5 mm.

Diagnosis. Circular to elongate species with coarse widely scattered ventral spines. Dorsal septum short. Ventral adductor scars elongate. Dorsal exterior smooth, spines, dimples and capillae all absent.

Description. Shell circular to elongate in outline. Hinge width about 0.6 to 0.7 of maximum width. Hinge extremities rounded or finely pointed. Convexity of ventral valve pronounced, no sulcus or median flattening. Umbo small, cicatrix very small, barely recognisable. Dorsal valve gently concave. Ventral interarea low. Delthyrium small, relatively high but narrow. Dorsal interarea distinct, low, thickened.

Ventral valve exterior with scattered spines in ill-defined pattern, widely spaced. Spines in one recumbent series with distinct row close to hinge. Spines relatively coarse at base, up to 0.9 mm wide, spaced at 2 to 4.2 mm at 15 mm from umbo. Ears small. Growth lines poorly developed.

Dorsal valve lacks spines, dimples and capillae. Growth lines feebly developed. External mould of holotype lacks dorsal spines and capillae.

Ventral valve interior with pair of small, divergent teeth. Adductor muscle scars deeply impressed, smooth with growth lines, elongate and bisected by low ridge. Diductor scars large, weakly impressed, smooth and flabellate. Anterior of muscle scars valve minutely pitted, pits arranged in radiating rows.

Dorsal valve interior with short, thickened median septum, constricted and thin at base of cardinal process. Adductor muscle scars indistinct, somewhat depressed, located either side of posterior portion of septum. Cardinal process low, wide, thickened, weakly bilobed. Dorsal valve with minor internal trail developed anteriorly and laterally.

Discussion. No other known species is closely comparable in morphological details. Antelo's (1972) report of *Heteralosia cornelliana* from correlatable strata of La Quebrada Larga, Rio Blanco, San Juan indicates a comparable species to *Coronalosia argentinensis* sp. nov. but with finer ventral spines as discussed above.

Genus **Guadalupelosia** gen. nov. Archbold & Simanauskas

Type species. *Strophalosia inexpectans* Cooper & Grant (1975: 795, pl. 269, figs 13–30) from the Getaway Member of the Cherry Canyon Formation, West Texas, USA. Wordian (Kazanian).

Diagnosis. Strophalosiinae with delicate fine spines on both valves. Short, delicate rhizoid spines on ears and near umbo. Body spines delicate, recumbent over entire surface, common on ventral valve, scarcer and hair-like on dorsal valve. Delthyrium small and narrow, teeth minute and delicate. Ears small, pointed. Dorsal interarea at close to 90° to plane of valve. Ventral adductors small, distinct, with raised rims above floor of valve. Cicatrix minute. Long thin dorsal median septum extends anteriorly to marginal ridge.

Discussion. When reviewing world strophalosiinids for the present study, the occurrence of the mid-Permian, West Texas species was noted. Although assigned to *Strophalosia* by its authors, the presence of dorsal spines precludes it from that genus. In fact, the distinctive morphological features of the species preclude its inclusion in any of the known Strophalosiidae reviewed by Brunton et al. (2000). The type species of *Guadalupelosia* was well described by Cooper & Grant (1975: 795–796, pl. 269, figs 13–30) based on four specimens. The species is exceedingly rare and represents a distinctive endemic genus within the West Texas Permian. The holotype of the species is specimen USNM 151299b, well figured by Cooper & Grant (1975: pl. 269, figs 17–23). The genus is formally named by us in order to avoid confusion over the type species' generic affinities in future palaeobiogeographical studies.

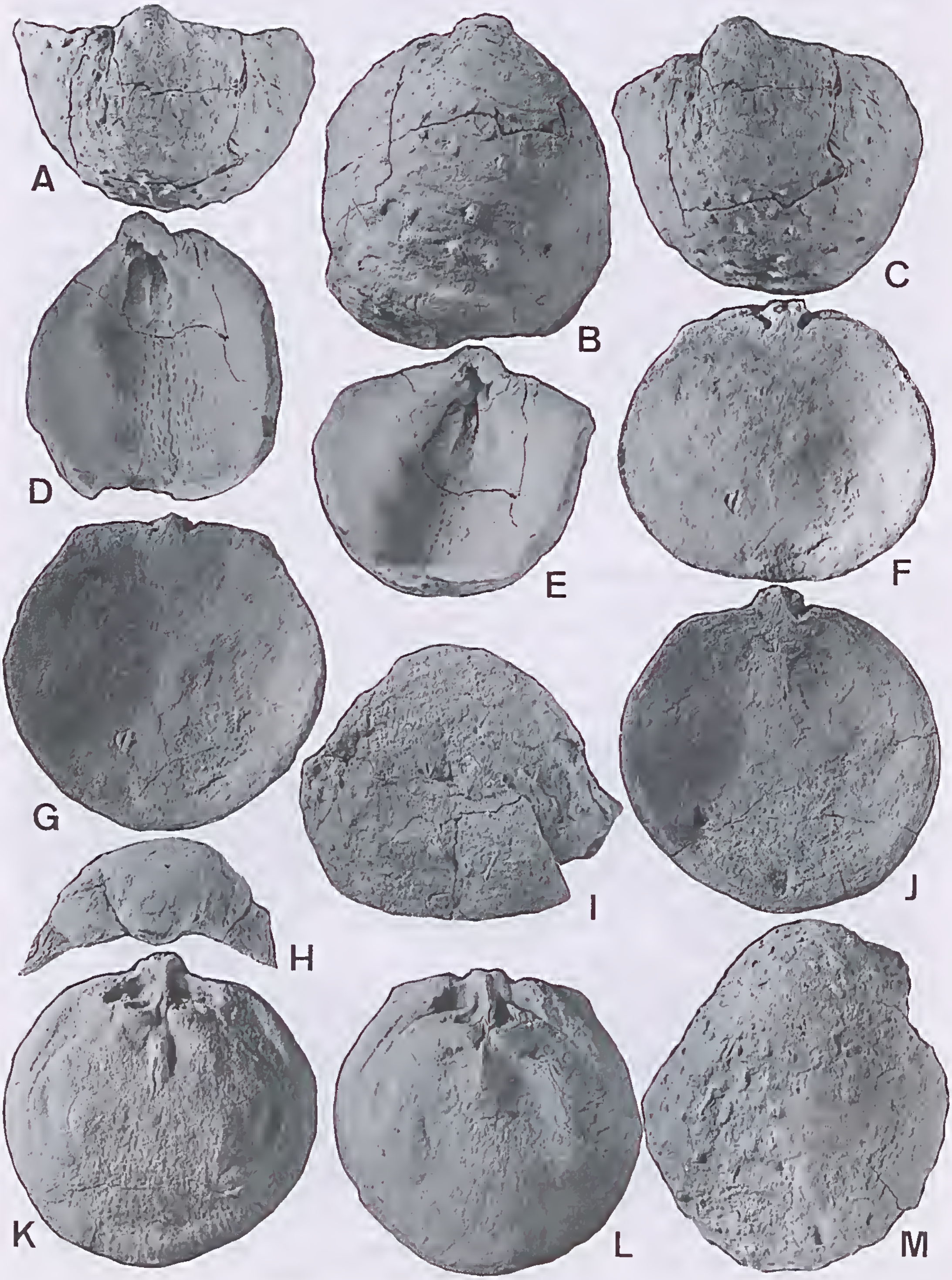
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Fig. 5. Tupelosia paganzoensis sp. nov. A–E, DCG-MLP 356e, ventral valve in posterior, ventral, and postero-ventral views, × 3, and interior and tilted anteriorly views, × 2.5. F, G, L, DCG-MLP 356n, dorsal valve in postero-dorsal, dorsal and interior views, × 3. H, I, DCG-MLP 356o, ventral valve in posterior and ventral views, × 3. J, K, DCG-MLP 356f, holotype, dorsal valve in dorsal and interior views, × 3. M, DCG-MLP 356p, ventral valve in ventral view, × 3.

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OBSERVATIONS ON *PONTICOCYTHEREIS TRICRISTATA* (BRADY, 1880) FROM THE ADMIRALTY ISLANDS, PAPUA NEW GUINEA AND COMMENTS ON QUATERNARY OSTRACOD EVOLUTION WITHIN THE SW PACIFIC OCEAN

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WARNE, M. T., 2001:12:17. Observations on *Ponticocythereis tricristata* (Brady, 1880) from the Admiralty Islands, Papua New Guinea and comments on Quaternary ostracod evolution within the SW Pacific Ocean. *Proceedings of the Royal Society of Victoria* 113(2): 229–235. ISSN 0035-9211.

The ostracod species originally described as *Cythere tricristata* Brady, 1880 from the Admiralty Islands, Papua New Guinea, appears to belong to the SW Pacific and Australasian genus *Ponticocythereis* McKenzie, 1967 (*sensu* Warne & Whatley 1996). This interpretation is based on the presence of some posterior pointing scale-like spines on the carapace surface of this species. SEM images of the type material for *Ponticocythereis tricristata* n. comb., which are presented here for the first time, enable the clear differentiation of this species from the very similar *Ponticocythereis ichthyoderma* (Brady, 1890), *Ponticocythereis quadriserialis* (Brady, 1890) and *Ponticocythereis laingensis* (Wouters, 1981). As a consequence of the subdued manifestation of scale-like or blade-like spines on adult specimens of *P. tricristata*, this species closely resembles juvenile rather than adult specimens of some other *Ponticocythereis* species. This ontogenetic/phylogenetic relationship suggests that paedomorphic processes were significant in the Quaternary evolutionary radiation of *Ponticocythereis* species within tropical SW Pacific and Australasian regions.

Key words: Recent, Ostracoda, Papua New Guinea, *Ponticocythereis tricristata*, paedomorphosis, Quaternary radiation.

SPECIES of the ostracod genus *Ponticocythereis* McKenzie, 1967 have a SW Pacific and Australasian biogeographical and palaeobiogeographical distribution. McKenzie's (1967) original generic diagnosis was reviewed by Whatley & Titterton (1981) and Warne & Whatley (1996) to accommodate a broader range of species and to more clearly define the valve/carapace morphological criteria characteristic of *Ponticocythereis*. A detailed discussion of the differential diagnoses between *Ponticocythereis* and a number of other closely allied genera is presented in Warne & Whatley (1996).

One of the species originally collected during the 'Challenger Expedition' and described by Brady (1880) was *Cythere tricristata*. Puri & Hulings (1976) selected and designated a carapace as a lectotype for this species (BM 80.38.121) from Brady's original collections housed in the Natural History Museum, London. [While this specimen is referred to as a lectotype in Puri & Hulings (1976), it has the annotation lectoholotype on the Puri & Hulings slide mount.] This lectotype specimen was collected from off the Admiralty Islands in water depths of 29 to 46 m.

Neither Brady's (1880) original illustrations, nor Puri & Hulings' (1976) light microscope photographs of this species are of adequate quality to clearly distinguish it from a number of other subsequently described and closely related taxa, such as *Ponticocythereis laingensis* (Wouters, 1981). In addition, no scanning electron microscope images of the type material of *Ponticocythereis tricristata* n. comb. have previously been available, rendering the differential diagnosis of this species obscure and identification difficult.

Perhaps as a consequence of the general perception that this species belonged to the genus *Actinocythereis* Puri, 1953 (ie. Yassini & Jones 1987: 823), *P. tricristata* has typically been overlooked in studies on SW Pacific and Australasian *Ponticocythereis* species. For instance, no mention was made by McKenzie (1986) in his discussion of various SW Pacific *Ponticocythereis* species. Further, Whatley & Titterton (1981) did not compare *P. tricristata* to their *Ponticocythereis spinosa*. Similarly, Wouters (1981) did not make comparisons with *P. tricristata* when describing *Actinocythereis laingensis* (Wouters original generic assignment—this species herein considered to belong to *Ponticocythereis*). The presentation of SEM images of the lectotype of *P. tricristata* in this paper, enables more complete differential diagnoses for SW Pacific *Ponticocythereis* species.

MORPHOLOGY AND PHYLOGENY

The lectotype specimen of *P. tricristata* illustrated here is a carapace. As a consequence it has not been possible to directly view its internal valve features. However, the specimen is semi-translucent, and when viewed in transmitted light the inner lamella in the anterior of the carapace is faintly visible. This internal feature appears to possess a width typical of adult *Ponticocythereis* species. In addition, the specimen is assumed to be an adult because of the presence of scale-like spines on the external surface (Fig. 1C–F). This type of spine development is not generally present on juvenile specimens of *Ponticocythereis* species (Warne & Whatley 1996). Further, the size of this specimen (length = 0.78 mm) is greater than or approximately equivalent to the adult size of other *Ponticocythereis* species occurring in tropical SW Pacific regions [ie. *P. manis* Whatley & Titterton, 1981 and *Ponticocythereis ichthyoderma* (Brady) *sensu* McKenzie, 1986], although all currently known tropical species are smaller than the largely temperate water *Ponticocythereis militaris* (Brady) *sensu* McKenzie, 1967 (pl. 13, fig. 4).

Lateral shape

Within the genus *Ponticocythereis* there are three broad groups of species which differ from each other in lateral outline. The first group includes the type species *Ponticocythereis militaris* Brady as well as *Ponticocythereis manis* Whatley & Titterton. Species within this group have very broadly rounded adult posterior lateral outlines (ie. McKenzie 1967: fig. 4o). The second group of species includes *Ponticocythereis ichthyoderma* (Brady) *sensu* McKenzie, 1986 and *Ponticocythereis quadriserialis* (Brady) *sensu* McKenzie, 1986, which have slightly less broadly rounded posterior margins than the first group of species (ie. McKenzie 1986: pl. 2, figs 13–14). The third group of species includes *Ponticocythereis laingensis* (Wouters) and *Ponticocythereis tricristata* (Brady), which—relative to the other two previously outlined *Ponticocythereis* species groups—have acutely rounded posterior margins (ie. Wouters 1981: pl. 2, fig. 1).

Spine development

Warne & Whatley (1996) emphasised the importance of posterior pointing scale and blade-like spines as a diagnostic characteristic of *Ponticocythereis* species. *Ponticocythereis* species can, however, also be subdivided into three species groups on the basis of the strength of this type of spine development. This subdivision in part parallels the three shape-based subdivisions previously outlined. The first group of species possesses well developed scale or blade-like spines and includes *Ponticocythereis militaris* and *Ponticocythereis manis*. In *P. militaris* lateral surface spines are usually strongly blade-like, although in some specimens some spines can develop a scale-like appearance (ie. Warne 1987: pl. 3, fig. A). In *P. manis*, spines are generally scale-like in well preserved adult specimens (ie. Warne & Whatley 1996: pl. 1, figs 1, 3–5, 6a, b). The second group of species includes *Ponticocythereis ichthyoderma* and *Ponticocythereis quadriserialis*. In these two species, scale-like expansions on the end of spines are less well developed than for *P. manis* (ie. Whatley & Titterton 1981: pl. 1, figs 1–7). Blade-like spines are not common in this second group of species suggesting a closer phylogentic link to *P. manis* than to *P. militaris*. The third group of species, which includes *P. laingensis* and *P. tricristata*, generally possess subdued terminal expansions on lateral surface spines. However, in *P. tricristata*, terminal spine expansions tend to be more scale-like than blade-like (Fig. 1C–F), whilst in *P. laingensis* spines tend to be more blade-like (ie. Wouters 1981: pl. 3, figs 2a–e).

Ontogenetic development

For *Ponticocythereis* species with well developed scale-like spines in the adult stage (ie. *P. manis*), it was noted by Warne & Whatley (1996) that scale-like spines are not developed in juvenile stages—not even in penultimate instars (ie. Whatley & Titterton 1981: pl. 2, fig. 12). As a consequence, Warne & Whatley (1996) speculated that scale-like spines might be a relatively recent evolutionary acquisition within *Ponticocythereis*. Another aspect of the ontogenetic development of most *Ponticocythereis* species, is the trend from more acutely rounded posteriors in juvenile stages to more broadly rounded posteriors in male and female adult forms (ie. Whatley & Titterton 1981: pl. 2, figs 1–5, 8–10, 12).

Phylogenetic development

One feature that distinguishes juvenile *Ponticocythereis* spp. specimens from *Actinocythereis* spp. specimens is the posterior pointing aspect of lateral

surface spines in the former (ie. Whatley & Titterton 1981: pl. 2, fig. 12; Wouters 1981: pl. 3, fig. 2f). Further, adult specimens of the third group of *Ponticocythereis* species outlined above (ie. *P. laingensis* and *P. tricristata*), which possess relatively poorly developed terminal spine expansions and/or acutely rounded posteriors, closely resemble *Actinocythereis* species except for the posterior pointing aspect of lateral surface spines (Fig. 1C–E).

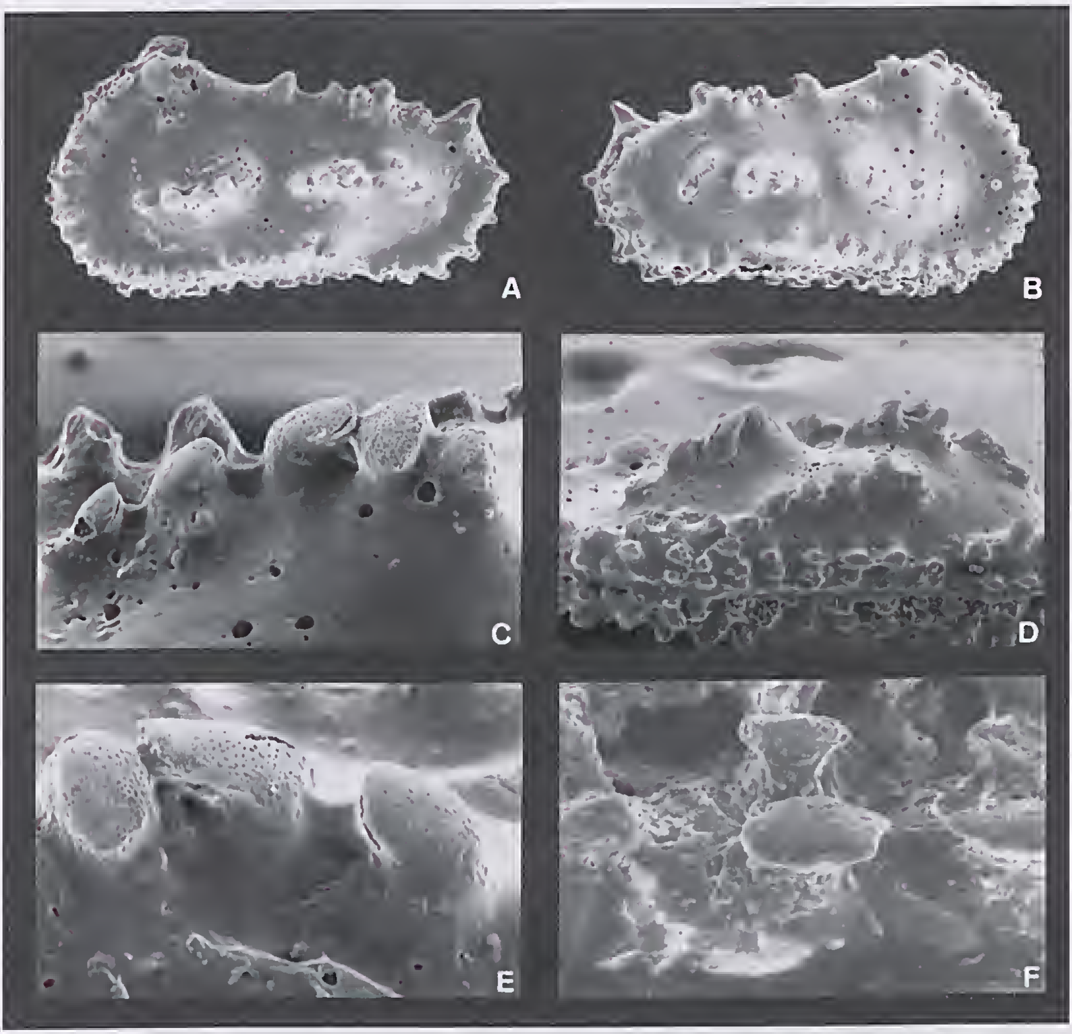


Fig. 1. Ponticocythereis tricristata (Brady, 1880); lectotype (BM 80.38.121); whole carapace; from off the Admiralty Islands, Papua New Guinea. A, external view of left valve; × 77. B, external view of right valve; × 75. C, oblique dorsal view of part of right valve showing anterior median rib spine cluster; anterior margin to left of image; × 286. D, oblique ventral view of ventral region of carapace and left valve showing ventral and median ribs and associated spine clusters; × 99. E, oblique dorsal view of part of left valve anterior median rib spine cluster; anterior margin to right of image; × 441. F, oblique ventral view of part of ventral margin of right valve showing scale-like spines; position of these spines along ventral margin is slightly posterior of mid-length; anterior margin to left of image; × 758.

Except for the better development of a median lateral surface rib, adult specimens of *P. laingensis* and *P. tricristata* also resemble juvenile specimens of some *Ponticocythereis* species such as *P. manis*. This suggests that juvenile characteristics, with respect to spine development and posterior outline, are being held over in the adults of this third group of *Ponticocythereis* species (*P. tricristata* and *P. laingensis*). Paedomorphic processes, therefore, appear to have been significant in the evolution of this particular group of *Ponticocythereis* species.

In addition, these *Ponticocythereis* species occur within the same restricted SW Pacific/Australasian biogeographic range as other *Ponticocythereis* species which is supplementary evidence for the classification of these taxa under this genus rather than *Actinocythereis s.l.* Interestingly, current records of modern-day *Ponticocythereis* species suggest that this genus is restricted to regions east of Wallace's line.

Evolutionary radiation

As noted by Warne (1987), the earliest currently known stratigraphical record of *Ponticocythereis* species is within the mid Miocene sequences of SE Australia. SE Australian fossil records suggest that *Ponticocythereis* species were initially adapted to warm temperate shallow marine regions with argillaceous sandy substrates. Two species are currently recognised from temperate modern-day waters of southern Australia (McKenzie 1967; Yassini & Jones 1995). However, a greater Recent diversity of modern-day *Ponticocythereis* species occurs in tropical regions of the SW Pacific Ocean [ie. *P. manis*, *P. ichthyoderma* and *P. quadriserialis* as well as the problematic *P. labiata* (Brady, 1890) and *P. spinosa* Whatley & Titterton, 1981 (for discussion of latter see under *Remarks* for *P. tricristata* in the section on Systematic Palaeontology)].

This Quaternary diversification within *Ponticocythereis* is part of a more general pattern of ostracod evolutionary radiation that appears to have occurred in the shallow tropical seas of the Indo–West Pacific region. For instance, *Pterobairdia* McKenzie & Keij, 1977 is perhaps the most striking example of a new taxonomic clade arising in this region during the Quaternary. If one accepts the argument presented here, that species such as *P. tricristata* and *P. laingensis* have a close phylogenetical relationship to other *Ponticocythereis* species, then paedomorphosis can be considered to be a contributing process in the adaptive radiation of Ostracoda apparent in Quaternary shallow marine realms of the SW Pacific region.

SYSTEMATIC PALAEONTOLOGY

Subclass OSTRACODA Latreille, 1806

Order PODOCOPIDA G. W. Müller, 1894

Suborder PODOCOPINA Sars, 1866

Superfamily CYTHERACEA Baird, 1850

Family TRACHYLEBERIDIDAE
Sylvester-Bradley, 1948.

Genus **Ponticocythereis** McKenzie, 1967

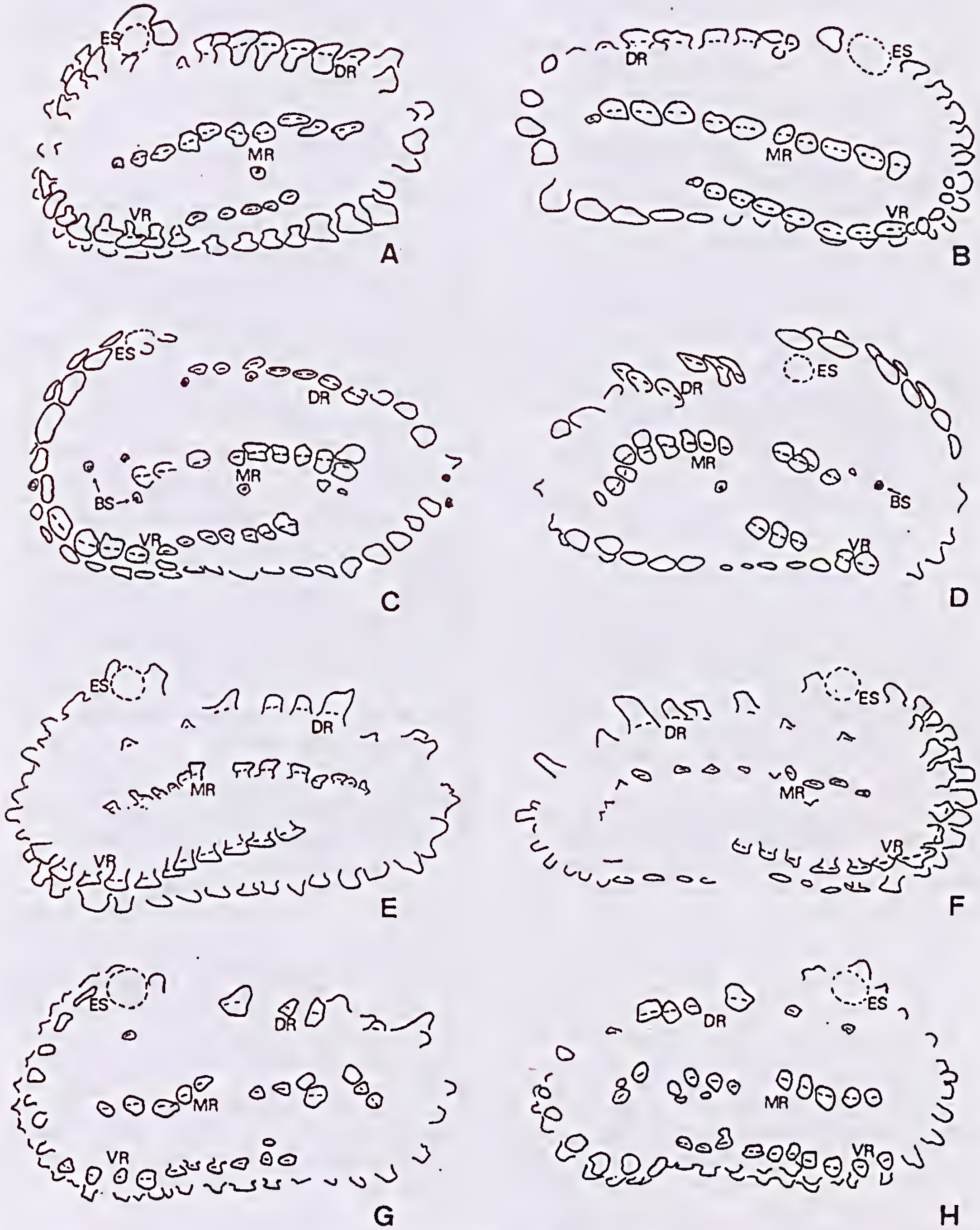
Type species. *Cythereis militaris* Brady, 1866.

Ponticocythereis tricristata (Brady, 1880)
n. comb.

Figs 1A–F, 2G–H

Cythere tricristata Brady, 1880: 110–111, pl. 23, figs 6a–d.
Cythere tricristata—Puri & Hulings, 1976: 292–293, pl. 15, figs 17–18.

Fig. 2. Spine position maps of similar SW Pacific and Australasian species of the genus *Ponticocythereis* McKenzie, 1976. *Abbreviations:* ES = eye spot; DR = dorsal rib; MR = median rib; VR = ventral rib; BS = broken spine). A, *Ponticocythereis militaris* (Brady, 1866) (NMV P122586); left valve; female; from latest Miocene sands in the Sherwood 18 Borehole, Western Port Basin, Victoria, Australia (based on SEM image in Warne 1987); × 62. B, *Ponticocythereis militaris* (Brady, 1866) (NMV J104); right valve; male; from recent tide pool at Seaholme, Port Phillip Bay, Victoria, Australia (based on SEM image in McKenzie 1967); × 64. C, *Ponticocythereis ichthyoderma* (Brady, 1890); lectotype (Hancock Museum Registration No. B453); left valve view; from recent of Sava-Sava Bay, Vanua Levu, Fiji (based on SEM image in McKenzie 1986); × 73. D, *Ponticocythereis quadriserialis* (Brady, 1890); lectotype (Hancock Museum Registration No. B454); right valve view; from recent shore sand, Artillery Point, Noumea (based on SEM image in McKenzie 1986); × 74. E, *Ponticocythereis laingensis* (Wouter, 1981); paratype (O.C.1091); left valve; female; from Laing Island, Hansa Bay, Papua New Guinea (based on SEM image in Wouters 1981); × 94. F, *Ponticocythereis laingensis* (Wouter, 1981); paratype (O.C.



1092); right valve; male; from Laing Island, Hansa Bay, Papua New Guinea (based on SEM image in Wouters 1981); × 101. G, *Ponticocythereis tricristata* (Brady, 1880); left valve of lectotype (BM 80.38.121) (based on SEM image in Fig. 1); × 77. H, *Ponticocythereis tricristata* (Brady, 1880); right valve of lectotype (BM 80.38.121) (based on SEM image in Fig. 1); × 74.

Material. 1 carapace (lectotype specimen—BM 80.38. 121) housed within the Natural History Museum, London.

Additional description. SEM images of the lectotype specimen of *P. tricristata* (Brady) indicate that the external carapace surface has the following features. Three longitudinal ribs (dorsal, median and ventral). Dorsal rib poorly defined, possessing 9–10 mostly posteriorly oriented and pointed spines. The main clusters of dorsal rib spines occur slightly posterior of mid-length. Median rib possesses three distinct clusters of posteriorly pointing spines. In addition, the anterior-most and middle median rib clusters are of terminally bulbous (semi scale-like) spines. In dorsal view, median rib consists of two distinct humps on which the anterior-most and middle clusters of spines rest. Anterior median rib cluster consisting of 4–5 individual spines. Middle median rib cluster consisting of 4 individual spines. Posterior median rib cluster consisting of 2–3 spines. Median rib spines minutely pitted. Ventral rib consisting of approximately 10 bulbous (semi scale-like) spines with a weakly posterior pointing aspect. Spines also present along anterior, ventral and posterior valve margins, being particularly dense along ventral margin. Some ventral margin spines are strongly scale-like in appearance. The carapace surface in between the three lateral ribs is mostly smooth. Eye spot very conspicuous. Anterior margin broadly rounded; posterior margin relatively acute for the family. For other descriptive comments see Brady (1880) and Puri & Hulings (1976), although details of all internal features are at present incompletely known.

Remarks. The spine position maps (Fig. 2) of *P. tricristata* (Brady, 1880), *P. ichthyoderma* (Brady, 1890), *P. quadriserialis* (Brady, 1890), *P. laingensis* (Wouters, 1981) and *P. militaris* (Brady, 1866) indicate that different species have different adult spine cluster patterns on lateral surface ribs.

With respect to the left valve holotype specimen of *P. spinosa* (Whatley & Titterton 1981: pl. 1, fig. 16), there are clear differences in external carapace morphology (shape and spine development) from the lectotype carapace specimen of *P. tricristata* illustrated here (Fig. 1A). However, a clear distinction between the two species is not apparent when comparing the right valve paratype specimen of *P. spinosa* (Whatley & Titterton 1981: pl. 1, fig. 14) with the right view of the lectotype carapace specimen of *P. tricristata* (Fig. 1B). Whatley & Titterton (1981) make no mention of a dual hump in the median rib in *P. spinosa*, which is clearly evident in dorsal or ventral view in *P. tricristata* as illustrated here (Fig. 1D) as well as in Brady's 1880 original illustrations (pl. 23, figs c, d). In addition, the length of the lectotype of *P. tricristata* measured from a left valve view is 0.78 mm, which is significantly longer than the length for adult specimens of *P. spinosa* as indicated by Whatley & Titterton (1981). Further detailed consideration of the status of *P. spinosa* is beyond the scope of this paper, although it is noted that McKenzie (1986) considered *P. spinosa* to be junior synonym of *Ponticocythereis quadriserialis*. *Ponticocythereis laingensis* (Wouters, 1981) is smaller and has a less well accentuated dual hump in the median rib than *P. tricristata*. The former also tends to possess blade-like spines in the adult form whilst the later tends to possess some bulbous, semi scale-like spines.

As a further taxonomic note, a northern Australian ostracod species originally designated as *Actinocythereis scutigera costata* Hartmann, 1978 (pp. 87–88; text figs 156–164; pl. 5, figs 6–9), was placed in the genus *Ponticocythereis* by Howe & McKenzie (1989) and redesignated as the species *P. costata*. It possesses ornament of strong ridges and, according to Howe & McKenzie (1989), some soft part anatomical features that perhaps suggest an affinity to *Ponticocythereis*. Howe & McKenzie (1989) also observed that A-1 and younger juveniles of this species possess 'flat-topped spines', although they did not illustrate these features. However, these spines are perhaps similar to those found in adult specimens of some *Ponticocythereis s.s.* species. It is possible that the 'flat topped spines' on juvenile specimens of *Ponticocythereis s.l. costata* fuse to form the strong ridges present on the carapaces of adult specimens. It is here considered that this species might have a close phylogenetic relationship to *Ponticocythereis s.s.* 'stock'. However, the adult carapace morphology of *Ponticocythereis s.l. costata* falls beyond the morphological limits for *Ponticocythereis* as redefined by Warne & Whatley (1996), and as a consequence this species is not here considered to belong to *Ponticocythereis s.s.* In addition, the appearance of 'flat-topped spines' in juveniles of this species are not features that appear in juvenile specimens of *Ponticocythereis s.s* spp. (*sensu* Warne & Whatley 1996). The lectotype specimen of *P. tricristata* is larger (greater in length) than male and female adult specimens of *Ponticocythereis s.l. costata* illustrated by Hartmann (1978), precluding the possibility that the former is a juvenile form of the later species.

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GERMINATION OF *XANTHORRHOEA AUSTRALIS* USING TREATMENTS THAT MIMIC POST-FIRE AND UNBURNT CONDITIONS

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Seed germination, using two different-aged seed batches of *Xanthorrhoea australis* Robert Brown, was carried out in growth cabinet trials using (i) treatments that mimic conditions of soils with a high charcoal content found after fire-stimulated flowering and (ii) on soils with little charcoal content and carrying ground cover which lessens light intensity, being conditions found after infrequent flowering that occurs without fire stimulation. Treatments were powdered charcoal, charcoal filtrate, gibberellic acid and differing light intensities. After 54 days, there was no significant difference ($P > 0.05$) in the number of germinants for each treatment, but in each treatment there were significant differences in the time taken to commence germination and the rate of germination. In full light, seeds stored for five years in paper bags at room temperature, germinated earlier than the seeds stored in the same way for one year ($P < 0.05$) at day 15. The difference was significant at day 18 with charcoal powder and light ($P < 0.01$) and also at day 15 in darkness ($P < 0.001$). Germination in light and charcoal filtrate was faster ($P < 0.05$ at day 18). In light reduced by a filter to 25% of the full intensity, seeds germinated earlier than those in brighter light ($P < 0.05$) at day 15, but not as early as seeds in darkness. Germination in the presence of gibberellic acid was faster in both light and darkness ($P < 0.001$) at day 21 and maximum germination was attained earlier than in other treatments. The results provide useful information on the management of *X. australis*, suggesting that seed may be stored for long periods and there is a beneficial effect when germination occurs under understorey species which later protect germinants from grazing.

Key words: cabinet trials, seed germination, *Xanthorrhoea australis*, charcoal, light variation.

THE spectacular post-fire flowering response of *Xanthorrhoea australis* is accepted as an adaptive response to fire. Many authors have recorded this phenomena (Willis 1970; Gill & Ingwersen 1976; Gill 1981; Gill & Groves 1981; Staff 1989). However, the species will also flower sporadically in the inter-fire period (Gill & Ingwersen 1976; Gill & Groves 1981; Staff 1989; Curtis 1996, 1998). Flowering in *X. australis* occurs early in the spring (August–September) when a large inflorescence may produce 1700–10 000 seeds (Staff 1975; Gill 1981). The following autumn, most of the seeds will be shed, but some will remain on the flower spike through the winter and will be shed the following spring or later (Curtis 1993, 1996). The sites used for germination field trials were in fenced areas 25 m square which provided different substrates and protection from grazing. In these sites very few surface sown seeds germinated and survived, whereas germinants of seeds buried to a depth of 3 mm had a survival rate of 27–42% (Curtis 1993, 1996).

The consequence of post-fire and sporadic inter-fire flowering is that the seeds are dispersed onto two different substrates. In the Mediterranean climate of north-east Victoria, natural fire events usually occur in the summer whilst prescribed burning is usually carried out in the autumn. As a consequence *X. australis* seeds fall 12 or 18 months after the fire onto soil carrying very little ground cover and a large amount of charcoal which has been leached by autumn and winter rainfall. When flowering occurs without fire stimulus, seeds fall onto soil which incorporates little charcoal and carries moss species, small plants, herbs and grasses and leaf litter (Curtis 1996) and an environment where the light intensity is probably lower. It was observed that in these sites *X. australis* seedlings were mainly growing in the protection of *Brachyloma daphnoides* (vascular plant nomenclature of Victorian species follow Ross 2000), a species widely distributed throughout the Warby Range State Park (Curtis 1993; Curtis 1996; Curtis 1998).

Prior to the research of Curtis (1993, 1996), there was no published research on the seed ecology and the early establishment of *X. australis*. However, Western Australian members of this genus are better studied (Bellairs & Bell 1990; Bell 1994; Bell et al. 1995), including the effect of gibberellic acid on some species. These, and the study of an eastern member of the genus, *X. johnsonii* (Peterson 1987), provided a background for the studies of Curtis (1993, 1996).

The results of Curtis (1993, 1996) showed that in growth cabinets, germination of *X. australis* seed harvested in the Warby Range State Park, was affected by temperature, light, stratification, and the time of seed picking. The optimum temperature for germination of 15–20°C in the laboratory matched field conditions during times of reliable rainfall in the Warby Range State Park. However, seeds kept in a diurnal alternating temperature of 12–20°C, or planted in the field in autumn, germinated six weeks earlier than those under a fixed temperature regime. Secondary dormancy was induced at 30°C and seven weeks later when the temperature was lowered to 20°C, the germination was significantly greater in darkness. Germination was greatly accelerated by the absence of light and by stratification at 4°C for 11 weeks. The time of seed harvest affected germination, with spring-picked seeds germinating significantly earlier than autumn-picked seeds, both seed types being picked in the same year.

Although the research provided information of the germination ecology of *X. australis*, it left many unanswered questions. Seeds produced in the same season that were picked later (in the spring), were found to be more responsive to darkness than seeds picked earlier (autumn). Would this response to darkness be similar in seeds that had been stored for a longer time? The presence of compounds produced after the wood of Californian chaparral species was heated to 175°C for 30 minutes increased germination (Keeley et al. 1985; Keeley & Pizzorno 1986). Curtis (1993, 1996) also found in laboratory and field trials in fenced plots that germination of *X. australis* seeds was earlier and more rapid in the presence of charcoal which darkened the surface of the substrate. Was this effect in *X. australis* seeds due to the darker soil color causing beneficial temperature differences, or chemicals associated with the charcoal? Would the presence of gibberellic acid cause earlier and more rapid germination in *X. australis* as it did in Western Australian members of the genus?

This study aims to determine the effect of (i) long-term storage of seeds, (ii) the presence of charcoal in a solid state, (iii) a solution made from a filtered suspension of charcoal powder in water, (iv) different light intensities and (v) gibberellic acid on the germination of *X. australis*.

MATERIALS AND METHODS

Seed collection

Xanthorrhoea australis seeds harvested in autumn (March–April) 1992 from a flowering in spring 1991 (five-year-old seed), were stored at room temperature and humidity, in sealed brown paper bags without added insecticide. Seeds harvested in the autumn of 1996 from a flowering in spring 1995 (one-year-old seed) were stored in the same way and used for all but one of the experiments. After each harvesting, the seed from at least 15 *X. australis* were mixed and before sowing, the seeds were inspected for damage or larval attack and any suspect seeds were rejected.

Laboratory trials

In March 1997, carbonised leaf bases from burnt *X. australis* plants were collected from the soil surface of an area in the Warby Range State Park, prescribed burnt in March 1996. At the time of collection, the carbonised leaf bases would have been subjected to the leaching effect of winter and spring rains which are the conditions in which *X. australis* seed germinate after prescribed burning the previous autumn. Three days later these were ground into a fine powder with a pestle and mortar, and 200 g of sieved charcoal powder was mixed in 500 ml of autoclaved distilled water. After mechanical agitation for 20 minutes, the solution was filtered and stored at 4°C. Another treatment used powdered charcoal sieved through a fine mesh to remove larger particles. The seeds were sown on previously autoclaved paper and imbibed with 10 ml of sterile distilled water. After sprinkling carbon powder over the seeds and paper, a further 3 ml of water was added.

In the differential light experiments, sheets of photographic neutral grey filter that completely covered the tray containing the petri dishes, were taped to the edge of the tray to exclude extraneous light from the petri dishes. Treatments used were: no filter (100% light), one layer (reducing the light to 50%), two layers (reducing the light to 25%) and 3 layers (reducing the light to 12.5%).

For each treatment, 10 seeds were sown in pre-sterilised plastic petri dishes on Whatman No. 182 seed test paper that had been previously autoclaved for 20 minutes at 121°C at 10^5 Newtons^2 (15 psi)

pressure. There were five replicates of each treatment. After sowing, the seeds were imbibed with 9 ml of autoclaved distilled water, the exceptions being the experiments using gibberellic acid and charcoal filtrate. A treatment using 9 ml of gibberellic acid (GA_3, 50 mg/L), were sown and continued for 54 days. The petri dishes were sealed with NescoFilm (Nippon Shoji Kaisaha Ltd, Osaka, Japan) tape and placed on opaque trays on the same cabinet shelf. At times of counting germinants, water was added where necessary to ensure complete imbibition and the dishes resealed.

The trials mimicked the conditions found in the Warby Range State Park, in spring and autumn when conditions are optimal for seed germination (Fig. 1). A temperature regime of 20°C day and 12°C night was used, with a regime of 12/12 h light/dark cycle and complete darkness. Limited cabinet availability restricted the choice to one temperature regime.

Germination occurred upon the emergence of the radicle. Cumulative totals of germinants were recorded each time data were collected. At the end of the trials, any ungerminated seeds were cut and examined for apparent viability (judged on the basis that the embryo was intact and there was no cell degradation).

Field and cabinet light measurement

In order to determine the light intensities required for the cabinet trials, the amount of light reaching the soil was measured by determining the percentage of light availability under the ground cover plants in three sites: two flat fenced sites burnt in 1976 and 1991 (with ungrazed ground cover species) and an unfenced site unburnt for about 100 years which had a northerly aspect. All sites had an overstorey of mainly *Eucalyptus blakelyi* and *E. macrorhyncha*, and a ground cover of mainly *Brachyloma daphnoides* and grass species. Field data were taken on 7 June 1997 between 10.15 a.m. and 12.20 p.m. A Quantum Sensor which measured the photo flux in micromols of photons m^{-2} $second^{-1}$ ($\mu M\ m^{-2}\ s^{-1}$) photosynthetic radiation (PAR) was used. To ensure that no reflected light was received from the operator, the measuring receptor was taped to a 600 mm long

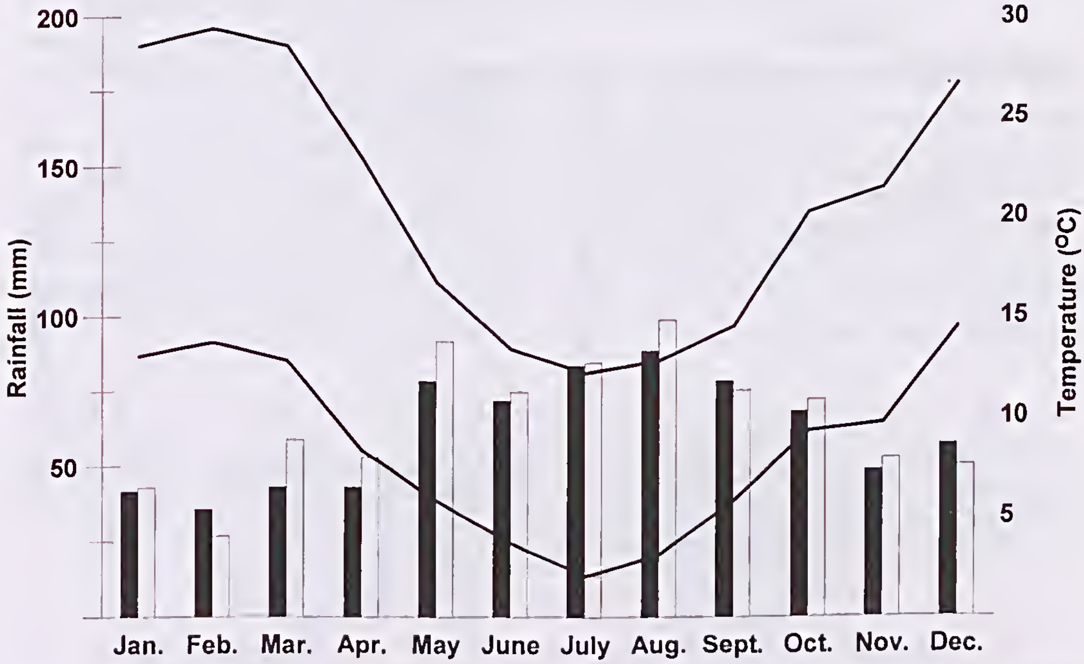

Fig. 1. Mean monthly rainfall at Wangaratta (dark bars) and Warby (light bars), and the mean monthly maxima and minima temperatures (continuous lines) at Wangaratta. Wangaratta data (Bureau of Meteorology, Melbourne), taken 16 km south-east of the study sites and Warby data (W. J. Wilson, Kala Rama, Wangandary, Victoria, 1975–1993) taken 6 km south-east of the study sites and at an altitude of 200 m (150 m lower than the study sites).

piece of unpainted wooden lath, 25 mm wide, held at arm's length. Forty measurements were taken with the receptor placed at ground level under the ground cover plants and at a height of 1 m above ground level. For all measurements, the receptor was kept parallel to the slope of the ground.

To measure photoflux levels in the cabinet trials, the receptor was placed with its top parallel to the shelf holding the seeds. Measurements were made with the doors closed and observations were made through a small observation window. Shelf measurements were the average of readings taken at 17 different points. Measurements of the photoflux under each of the light reducing filters were the average of three readings.

Statistical analysis

The number of seeds that germinated in each of the treatments was compared by one-way ANOVA using Minitab (Release 7; Minitab Inc. 1989); confidence intervals, where not expressed by Minitab, were calculated using tables published by Neave (1978). Statistical treatments mostly followed Fowler & Cohen (1990). Statistical calculations were based on the number of germinants and not the percentages.

RESULTS

Photoflux measurement

The average photoflux levels in the field sites below a ground-layer canopy was 10–51% of that found 1 m above the ground under the overstorey. In all sites there was a wide variation in all data (Table 1). The cabinet range of photoflux levels was 49–67 μM m^{-2} s^{-1} with an average of 58. In the differential light experiment the readings were: no filter (100% light) 63, one filter layer (50% light) 29, two filter layers (25% light) 14.5 and three filter layers (12.5% light) 6.75 μM m^{-2} s^{-1} (Table 2).

Light intensity	Average reading
Full light	58.4
50.0% light	29.0
25.0% light	14.5
12.5% light	6.75

Table 2. Photosynthetic Radiation (PAR) readings in growth cabinet, taken in full light on open shelf and under filters that reduce the light intensity to 50%, 25% and 12.5% of the full light. Shelf photoflux was average of 17 readings and photoflux under each light reducing filter was the average of three readings. Photoflux readings were measured in micromols m^{-2} second^{-1}.

Cabinet trials

Fifty-four days after commencing trials, storage, light, charcoal as a solid and filtrate, and gibberellic acid, had few detectable effects on the germination of *X. australis*. However, some minor trend differences in the breaking of dormancy and germination rates were observed (Figs 2–6).

The effect of storage on seeds had no significant effect on germination. Light broke dormancy faster in the earlier picked seeds than the later picked seeds, but in darkness the later picked seeds had more rapid germination (Fig. 2).

In light and the presence of charcoal powder, seeds broke dormancy three days earlier and had increased initial germination and number of germinations in the first three weeks. However, the overall effect was that untreated seeds had slightly better germination. In the dark, dormancy was broken earlier and germination was more rapid in the untreated seeds, but at day 54 both treatments had the same germination (Fig. 3).

Site fire history	Position of measuring receptor	Average photoflux reading	Maximum photoflux reading	Minimum photoflux reading
Burnt 1991	1.0 m above ground	228	690	40
	under ground cover plants	91	450	3
Burnt 1976	1.0 m above ground	162	700	10
	under ground cover plants	115	480	15
Unburnt	1.0 m above ground	286	470	50
	under ground cover plants	126	390	30

Table 1. Photosynthetic Radiation (PAR) readings taken in field sites in the Warby Range State Park, north-east Victoria, that underwent prescribed burning in 1991 and 1976 and an unburnt site. Readings were taken at ground level under ground cover plants and 1.0 m above ground level. Photoflux readings were the average of 40 readings taken on 7 June 1997 between 10.15 a.m. and 12.20 p.m., and were measured in micromols m^{-2} second^{-1}.

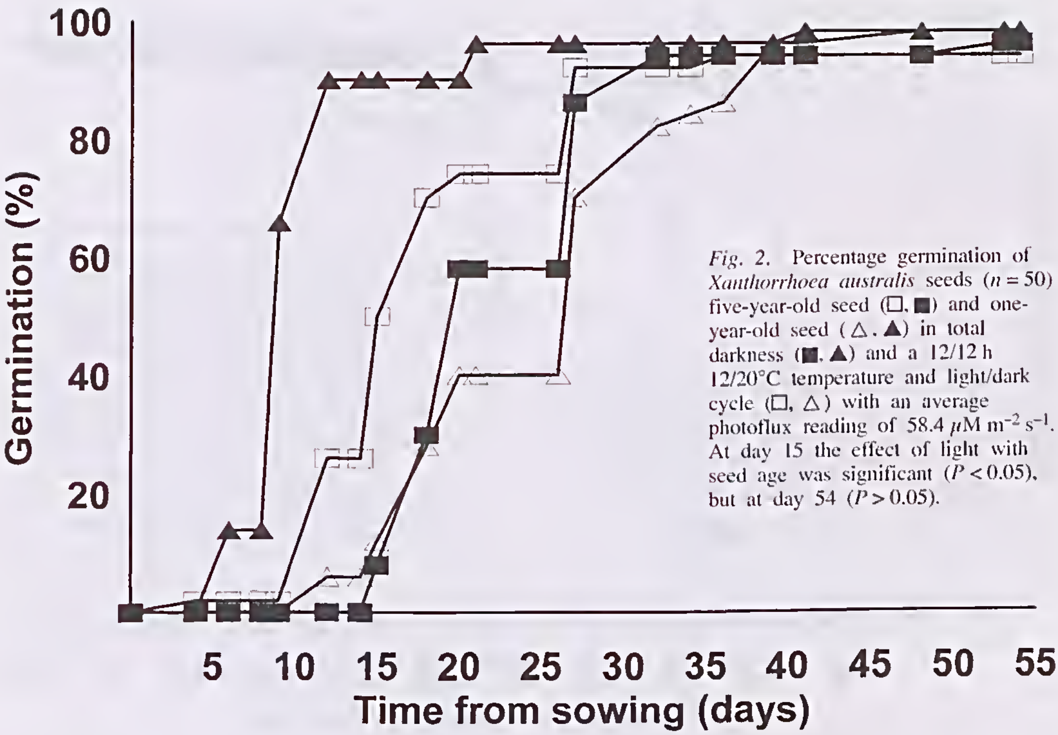

Fig. 2. Percentage germination of *Xanthorrhoea australis* seeds ($n = 50$) five-year-old seed (□, ■) and one-year-old seed (△, ▲) in total darkness (■, ▲) and a 12/12 h 12/20°C temperature and light/dark cycle (□, △) with an average photoflux reading of 58.4 μM m^{-2} s^{-1}. At day 15 the effect of light with seed age was significant ($P < 0.05$), but at day 54 ($P > 0.05$).

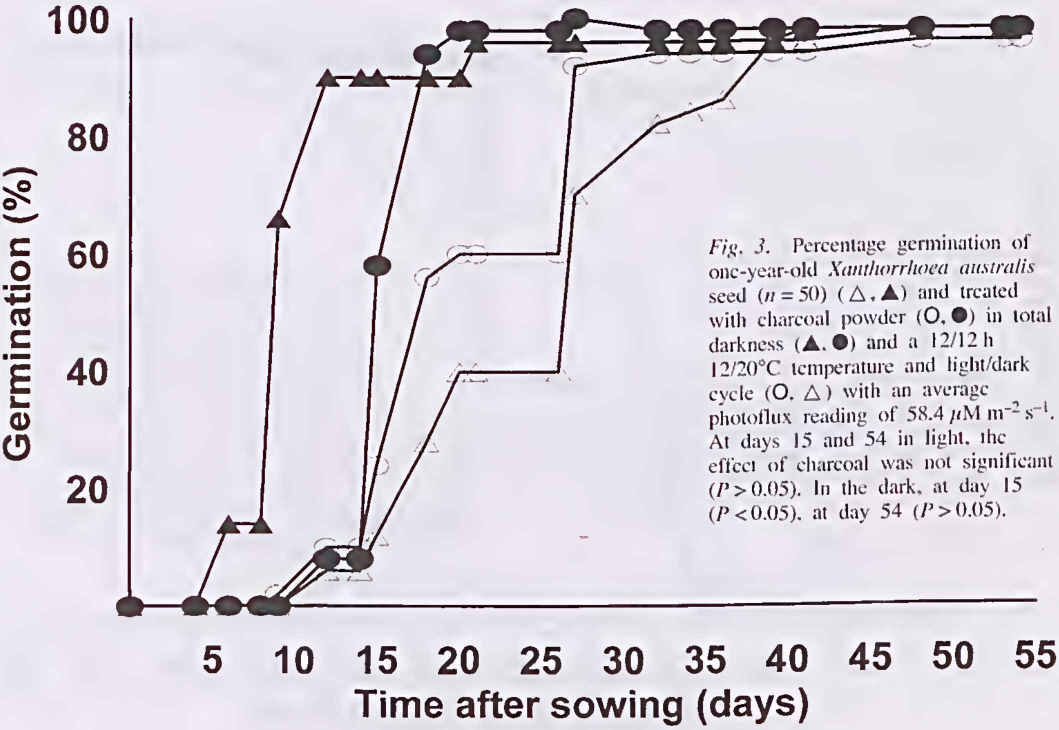

Fig. 3. Percentage germination of one-year-old *Xanthorrhoea australis* seed ($n = 50$) (△, ▲) and treated with charcoal powder (O, ●) in total darkness (▲, ●) and a 12/12 h 12/20°C temperature and light/dark cycle (O, △) with an average photoflux reading of 58.4 μM m^{-2} s^{-1}. At days 15 and 54 in light, the effect of charcoal was not significant ($P > 0.05$). In the dark, at day 15 ($P < 0.05$), at day 54 ($P > 0.05$).

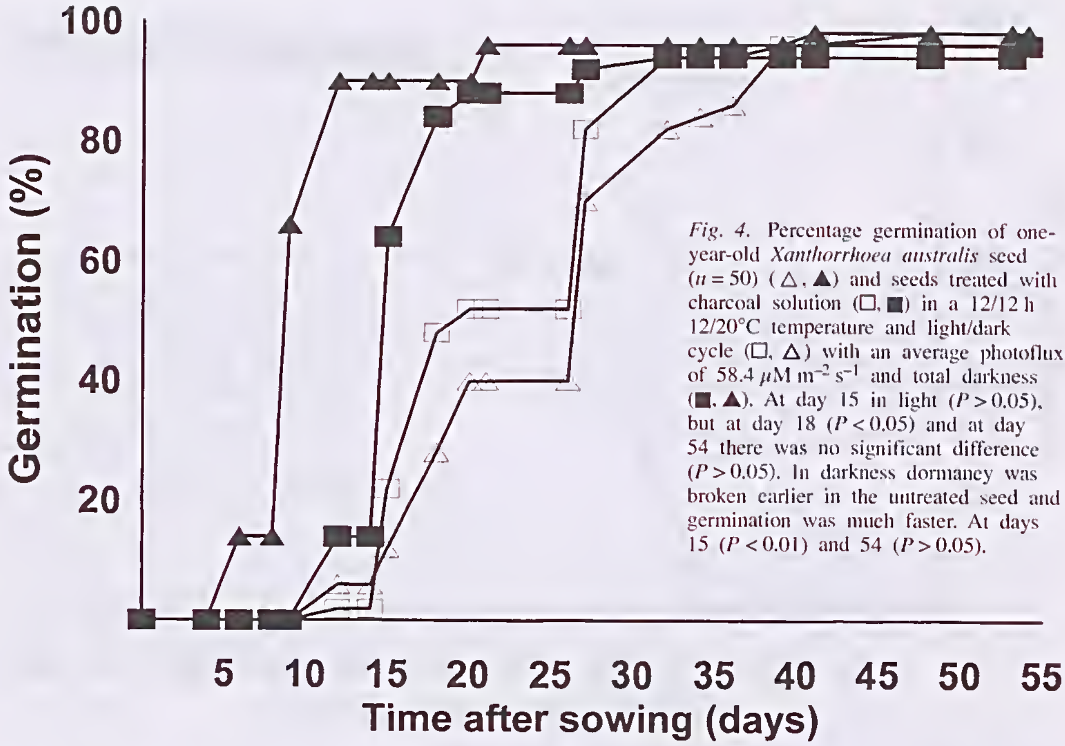

Fig. 4. Percentage germination of one-year-old *Xanthorrhoea australis* seed ($n = 50$) (△, ▲) and seeds treated with charcoal solution (□, ■) in a 12/12 h 12/20°C temperature and light/dark cycle (□, △) with an average photoflux of 58.4 μM m^{-2} s^{-1} and total darkness (■, ▲). At day 15 in light ($P > 0.05$), but at day 18 ($P < 0.05$) and at day 54 there was no significant difference ($P > 0.05$). In darkness dormancy was broken earlier in the untreated seed and germination was much faster. At days 15 ($P < 0.01$) and 54 ($P > 0.05$).

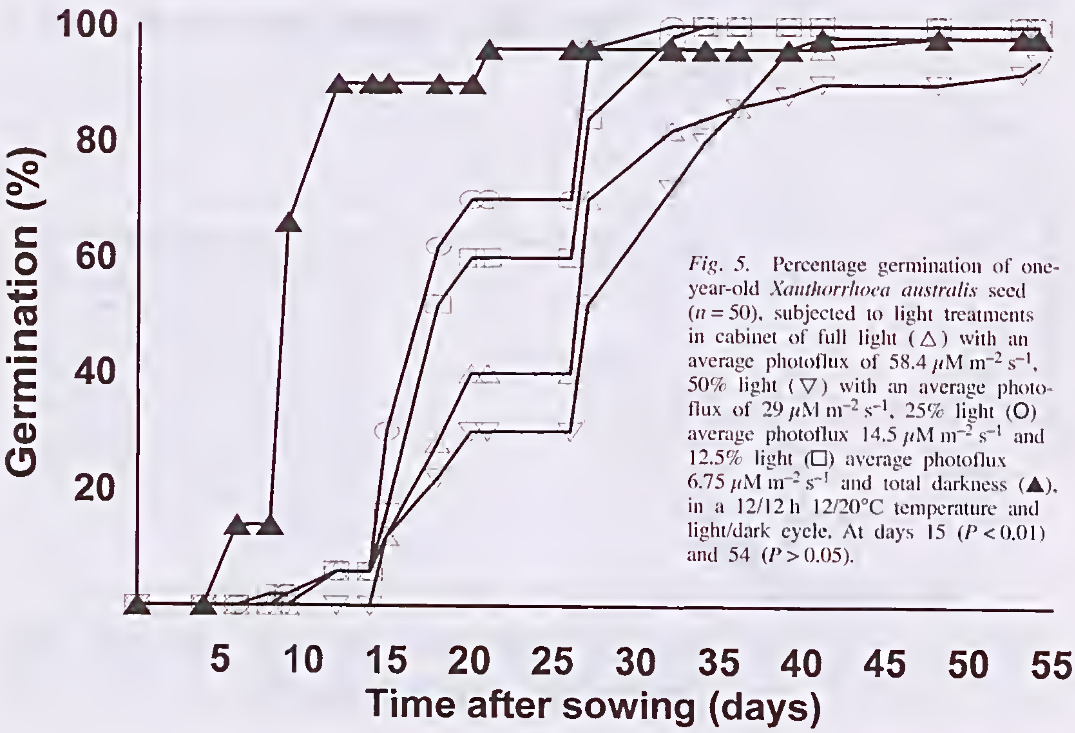

Fig. 5. Percentage germination of one-year-old *Xanthorrhoea australis* seed ($n = 50$), subjected to light treatments in cabinet of full light (△) with an average photoflux of 58.4 μM m^{-2} s^{-1}, 50% light (▽) with an average photoflux of 29 μM m^{-2} s^{-1}, 25% light (O) average photoflux 14.5 μM m^{-2} s^{-1} and 12.5% light (□) average photoflux 6.75 μM m^{-2} s^{-1} and total darkness (▲), in a 12/12 h 12/20°C temperature and light/dark cycle. At days 15 ($P < 0.01$) and 54 ($P > 0.05$).

Charcoal filtrate did not significantly reduce the time to break dormancy in light, but germination was more rapid than in the untreated seeds. In darkness, dormancy was broken five days earlier in the untreated seed and maximum germination was achieved earlier, but overall there was little difference between the treated and untreated seeds (Fig. 4).

Seeds germinating in the 25% light intensity broke dormancy earlier than in full light and the other light intensities, although not as early as seeds germinating in darkness. For about the first two weeks, the germination was greater in the 25% light, and commencement of germination of the seeds in the 50% light was delayed more than those in the 12.5%, 25% light and darkness, but overall none of the light treatments increased final germination significantly (Fig. 5).

In light and darkness, for the first two weeks, the presence of gibberellic acid had no significant effect on seed germination. However, a week later, seeds in a light regime had greater germination and reached a maximum of 98%, 21 days earlier than the untreated seeds. Because of cabinet problems, the experiment with GA_3 was terminated at day 27, when the treated seeds in the dark regime had 100% germination and it was not until day 40 that the untreated seeds in the dark regime had a similar germination rate (Fig. 6).

At the conclusion of the trials any ungerminated seeds were cut open and the embryo examined. In all of these the testa was found to be intact but the endosperm had decayed.

DISCUSSION

Flowering of *X. australis* in the absence of fire is spasmodic and irregular (Staff 1975; Curtis 1993, 1998). Fire-stimulated flowering results in a substantial seed crop that is available for germination the following autumn. The studies of Bellairs & Bell (1990), Bell et al. (1995), Curtis (1993, 1996), and the present study, have shown that there is little difficulty in germinating seeds of many species of the *Xanthorrhoea* genus. However, the key to successful longer-term regeneration of *X. australis* is the subsequent survival of germinants and seedlings (Curtis 1993, 1998).

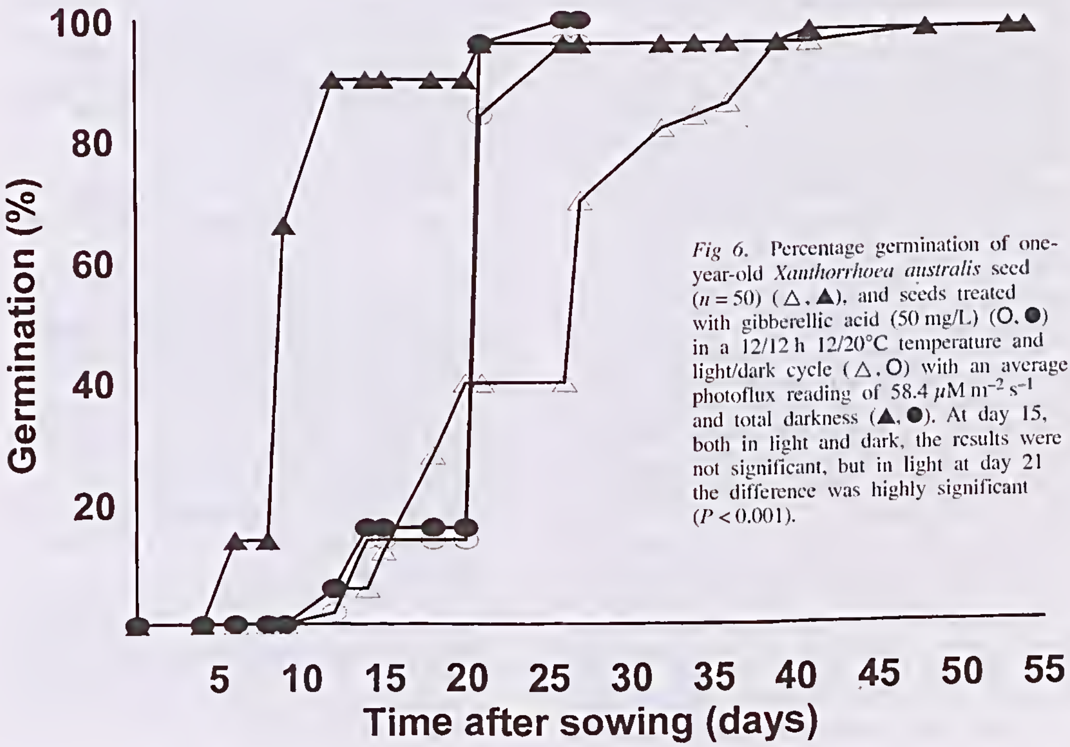

Fig 6. Percentage germination of one-year-old *Xanthorrhoea australis* seed ($n = 50$) (△, ▲), and seeds treated with gibberellic acid (50 mg/L) (O, ●) in a 12/12 h 12/20°C temperature and light/dark cycle (△, O) with an average photoflux reading of 58.4 μM m^{-2} s^{-1} and total darkness (▲, ●). At day 15, both in light and dark, the results were not significant, but in light at day 21 the difference was highly significant ($P < 0.001$).

It was found that young seeds germinate earlier and faster in total darkness, whereas old seeds germinate earlier and faster in light (Fig. 2). This suggests that a mixture of older and newer seeds would increase the number of germinants in areas requiring re-establishment of *X. australis*.

In controlled environment cabinet trials with *X. australis*, the presence of charcoal or charcoal filtrate affected dormancy of seed in light but not in darkness (Figs 3, 4). Carbonisation of material may not be necessary, because heating chaparral shrub material to 175°C for 30 minutes has produced water soluble compounds that stimulate germination (Keeley et al. 1985; Keeley & Pizzorno 1986). Alternatively, the charcoal from the burnt *X. australis* used in this study, may have been leached for about one year, lessening the effect of any (potential) stimulatory compound. Since germination in darkness was unaltered by the presence of charcoal, it would appear that any beneficial effect of charcoal may be due to the temperature advantage of the darker soil because of greater absorption of radiant heat from sunlight (Curtis 1993, 1996). In field trials on flat sites, Curtis (1993, 1996) found that *X. australis* seed buried 3 mm deep in soils darkened with charcoal after fire, germinated earlier and faster than in soils containing little or no charcoal. However, in this experiment no measurement of soil temperature by heat probes was done.

Curtis (1993, 1998) found that in two sites unburnt for many years, numerous seedlings were growing amongst ground cover plants such as *Brachyloma daphnoides*, where there is protection and a lower light intensity than in open areas. The present cabinet trials showed optimum germination occurred in total darkness, with germination better in light values of 25% and 12.5%, than in 50% (Table 2). This was within the relative values of light readings found under the ground cover plants in most sites. The exception was an unburnt site, where readings were taken around noon, which could have accounted for the higher light readings. Since optimum germination conditions occur in total darkness, the faster germination in lower light intensities would increase the time span when conditions are more favourable for germination. The ecological benefit of this could be when a dry spring was followed by a wetter than normal summer, when seeds would germinate in conditions of longer days and shorter nights. Temperatures in summer could be lower under ground cover plants than in open ground. This may help keep seeds in the optimum temperature for *X. australis* seeds of 20/12°C (Curtis 1993, 1996). In some sites dense moss mats may insulate soil (Curtis 1993, 1996) and in early summer the moss may also lessen moisture loss, which would result in better imbibition. However, no temperature or moisture data were taken to substantiate this hypothesis.

Light inhibition of *X. australis* seeds was lessened by the presence of charcoal, charcoal solution and gibberellic acid. In the presence of gibberellic acid, the response to light of *X. australis* seeds was similar to two Western Australian species, *Xanthorrhoea preisii* and *X. gracilis*. Seeds of the former responded at 15°C and 23°C, and the latter at 15°C. Bell et al. (1995) suggested the response may be due to involvement of the light sensing pigment called phytochrome.

The presence of smoke can have a beneficial effect on seed germination of many plant species (Brown et al. 1994; Dixon et al. 1995). In Western Australia, the need to rehabilitate areas disrupted by mining has encouraged research into the effect of smoke on seed germination, but seeds of the *Xanthorrhoea* genus have not been among those studied by Dixon et al. (1995), Grant & Koch (1997) and Roche et al. (1997). However, although the presence of charcoal, both as a powder and filtrate, stimulated earlier germination of *X. australis* seeds in light and delayed it by a week in darkness (Fig. 3), it did not significantly affect the final number of germinants. It is possible that direct application of smoke might have the same result. However, the presence of gibberellic acid in light speeded up the germination rate in light but retarded germination in darkness. The presence of charcoal and charcoal filtrate had similar effect.

The germination research by Curtis (1993, 1996) and the present study has provided useful information on the management of *Xanthorrhoea australis*:

- When sowing in autumn or early spring, the seeds should be buried to a depth of 3 mm.
- For rapid germination, keep imbibed seeds in darkness at 4°C for 11 weeks before sowing.
- Viability is maintained in seeds stored at room temperature and humidity in brown paper bags for at least five years without insecticides, providing no larvae are present.
- There could be an increased germination by using a mixture of older and newer seeds because of their differences in germination in darkness and light.
- The presence of understorey species lessen light intensities which helps germination and also provides protection from grazing, particularly from rabbits. This should be considered by managers when developing burning prescriptions.

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WILLOW GROVE, RAINBOW AND PIGICK: THREE NEW METEORITE FINDS IN VICTORIA, AUSTRALIA

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Three new and distinctive meteorites have recently been discovered by chance during ploughing activities in Victoria. The Rainbow and Pigick meteorites were found together near Rainbow in the Mallee region, and the Willow Grove meteorite in the Latrobe Valley. Rainbow, consisting of two stones totalling 1.55 kg, shows characteristics of the rare class CO3 carbonaceous chondrites. Pigick, consisting of eight stones totalling about 600 g, is an H5 ordinary chondrite showing weak to moderate shock features. Willow Grove, made up of two masses of 9 and 2.7 kg, is an anomalous ungrouped ataxite with one of the highest known nickel contents (average 28%). It has a unique structure consisting almost entirely of lath martensite, formed by shear transformation of high temperature austenite with no apparent kamacite.

Key words: Rainbow meteorite, CO3 carbonaceous chondrite, Pigick meteorite, shocked features, Willow Grove meteorite, Ni-rich ataxite, plate martensite, Victoria.

FROM time to time, farmers in the more arid parts of Victoria by chance discover meteorites (eg. the Turriff meteorite from the Mallee region (Birch 1999). Two recent finds are from near the small town of Rainbow, in the Wimmera region. A total of ten fragments (Table 1; Fig. 1) were found in 1994 by Darryl Wedding while he was ploughing wheat paddocks about 12 km west of the town. Eight of these fragments, totalling 690 g, represent a single H5 ordinary chondrite, and have been named Pigick, after the local parish. The other two pieces, with a total weight of 1.55 kg, are of a rare carbonaceous chondrite (type CO3), which has been named Rainbow, after the nearest town. Both pieces of Rainbow and four fragments of Pigick (~ 360 g) were donated to Museum Victoria by the finder.

The third recent meteorite discovery was not in semi-arid Victoria, but in the much wetter Latrobe Valley, in the south-east of the State. David Buckley ploughed up two pieces (Fig.2) of an iron meteorite, totalling 11.7 kg, on his farm near the township of Willow Grove, 110 km ESE of Melbourne. The smaller piece (2.7 kg) was discovered in 1995, the larger (9 kg) in 1998. The meteorite has been classified as an ungrouped Ni-rich ataxite and named Willow Grove, after the nearest town. The larger piece was retained by the finder, but the smaller was donated to Museum Victoria.

All three meteorite names have been approved by the Nomenclature Committee of the Meteoritical Society. Both Willow Grove and Rainbow are highly unusual meteorites and are currently being investigated in more detail (Grossman et al. 2000; Scorzelli et al. 2000; Birch et al. 2001).

	MV Cat. No.	Dimensions (mm)	Mass (g)
Rainbow	E15238	135 × 90 × 65	1132
	E15237	95 × 70 × 45	421
Pigick	E15239	80 × 55 × 40	169
		65 × 50 × 30	156
		not measured	*c.* 110
	E15241	55 × 40 × 30	103
	E15242	65 × 35 × 25	63
		48 × 45 × 25	58
	E15240	35 × 25 × 15	26
		35 × 20 × 10	8

Table 1. Approximate mass and size for the pieces of the Rainbow and Pigick meteorites. Specimens without MV numbers are held by the finder. E15241 has been reduced to 80 g during investigation.

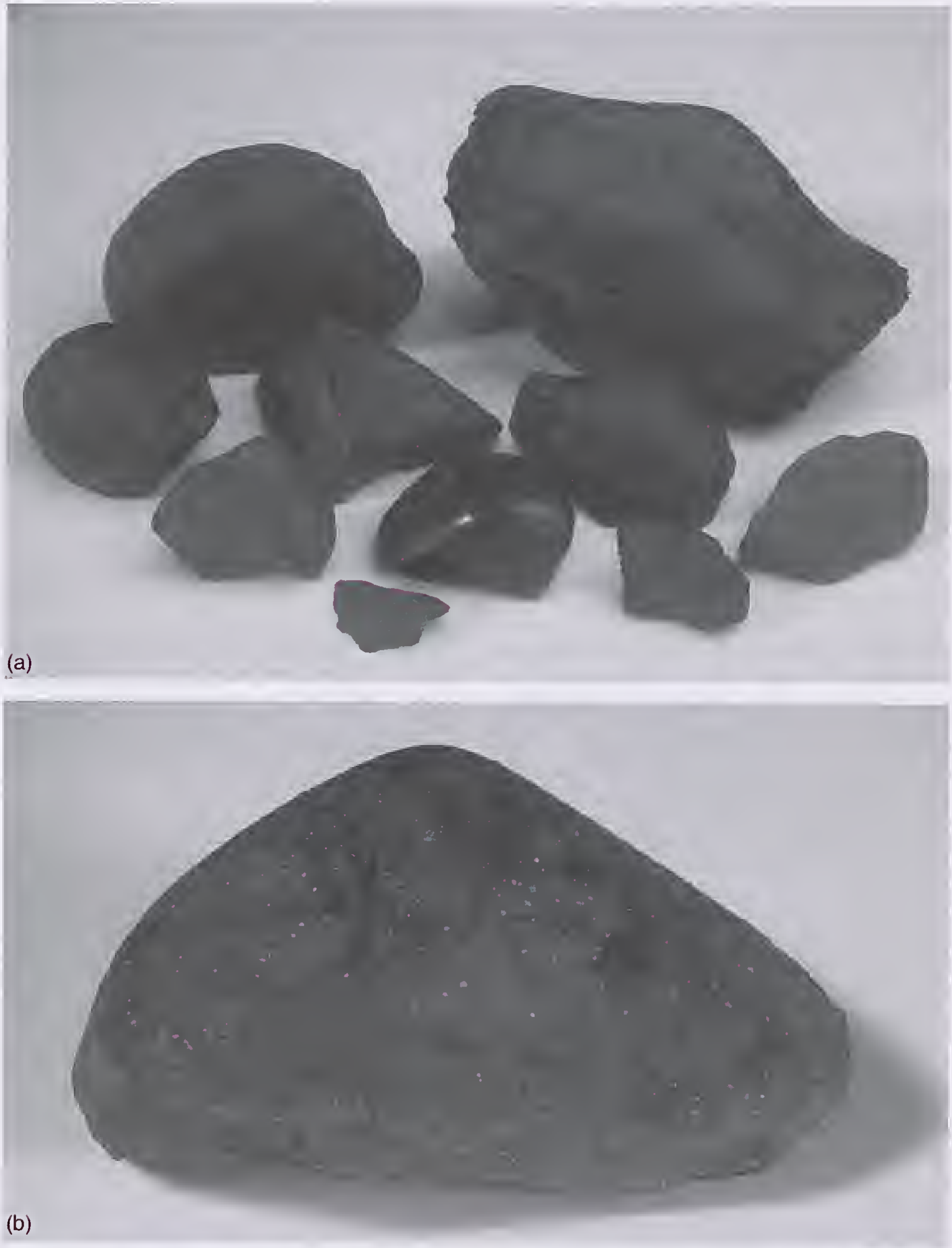

Fig. 1. (a) Rainbow meteorite (two large stones at rear) and Pigick meteorite (smaller stones). The Pigick stone at centre-front was polished by the finder. The larger Rainbow stone is 135 mm long. (b) The second largest Rainbow stone showing pale-colored chondrules on the weathered surface (stone is 95 mm long).

Fig. 2. The Willow Grove meteorites. (a) 2.7 kg mass (100 × 70 × 70 mm). (b) 9 kg mass (160 × 160 × 110 mm).

THE RAINBOW METEORITE

Location

The two pieces of the Rainbow meteorite were found in allotment 8, Parish of Pigick, about 1 km apart, along an approximate E–W line (Fig. 3). The geographic coordinates are approximately 35°54.4′S.141°51.3′E. The site is sandy soil derived from the Cainozoic sediments of the Murray Basin; no hard rock outcrops are known in the region.

Appearance and mineralogy

The two stones weighed 1.132 kg and 421 g when discovered, with dimensions 135 × 90 × 65 mm and 95 × 70 × 45 mm, respectively. They appear highly weathered, with a smooth, dark brown exterior surface, on which abundant chondrules can be made out under the microscope. Some irregular films of reddish brown iron oxide, with small embedded quartz grains derived from the surrounding soil, may represent original fusion crust.

In thin section, iron oxide veining is common and silicate minerals are heavily stained. Chondrules are distinct and abundant, almost all less than 0.5 mm across, with most less than 0.2 mm (Fig. 4). They are set in a very fine-grained, near opaque matrix. The most common type of chondrule contains porphyritic olivine and orthopyroxene, but others consisting of cryptocrystalline and barred olivine and porphyritic olivine are also present. Olivine compositions obtained by electron microprobe analysis are markedly heterogeneous, ranging from Fa_{45} to $Fa_{0.2}$. There is a broad peak between Fa_0 and Fa_7 (Fig. 5). Many low-FeO olivines have extremely high CaO contents, exceeding 0.4 wt. %. Grains of orthopyroxene are also present. They are low in FeO, with compositions in the range $Fs_{0.5-7.4}Wo_{0.4-4.6}$, averaging $Fs_{3.4}Wo_{1.6}$. Other minerals detected included rare Ca-rich plagioclase in the groundmass and uncommon tiny grains of kamacite (4.8–14.4% Ni; 0.27–1.2% Co), taenite (43.1% Ni) and troilite.

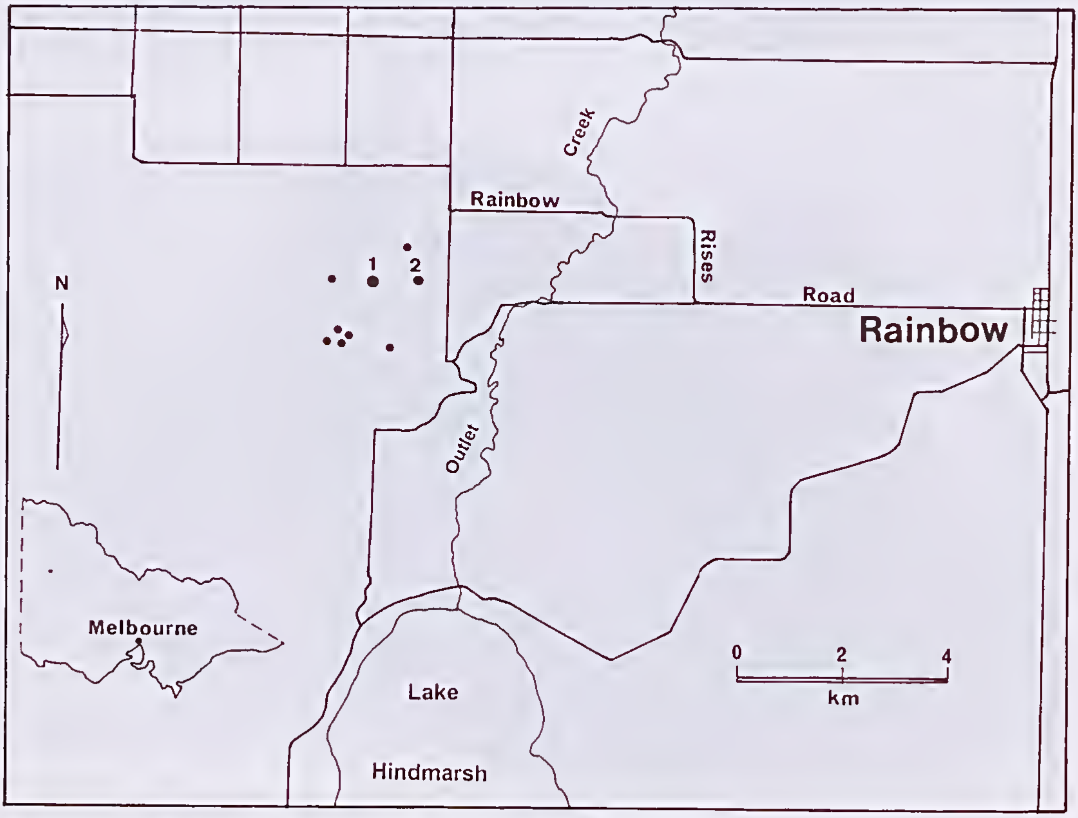

Fig. 3. Locality map for the Rainbow (1 and 2) and Pigick meteorites.

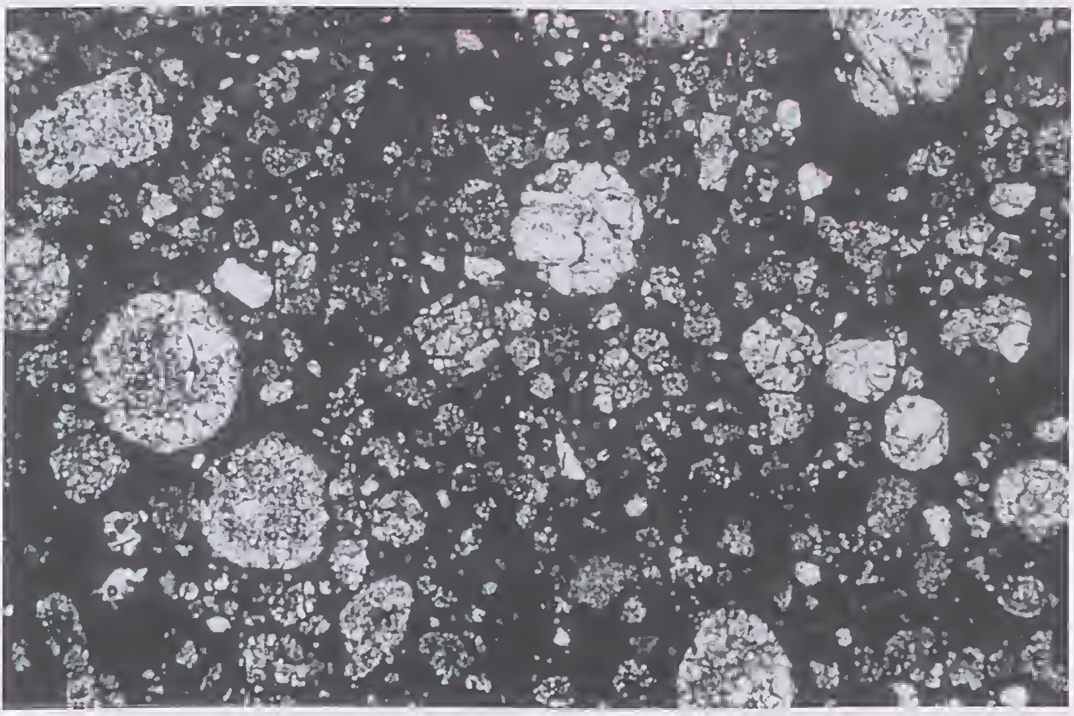

Fig. 4. Thin section of Rainbow showing typical chondrules (largest is 0.45 mm across).

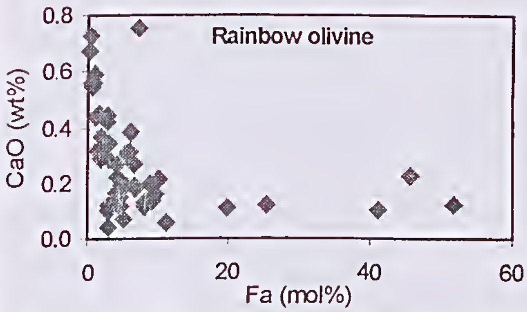

Fig. 5. Olivine compositions in Rainbow (from Grossman et al. 2000).

The presence of amoeboid olivine inclusions (AOIs) and fine-grained calcium–aluminium inclusions (CAIs) was also noted (Grossman et al. 2000). The AOIs contain thin veins (0.4–0.8 μm) of olivine (~ Fa_8) crosscutting larger crystals of forsterite ($Fa_{1.8}$). Small irregular grains of anorthite and diopside are dispersed through the AOIs.

The mineralogy of the meteorite strongly resembles that of the rare CO3 class of carbonaceous chondrites. Only about 20–25 distinct CO3 meteorites are known, with Rainbow being the seventh from outside Antarctica and the Sahara.

Thermoluminescence and O-isotopes

Additional techniques have been used to classify the Rainbow meteorite. These are reported in more detail by Grossman et al. (2000). On a scale from 3.0 to 3.7, CO3 meteorites show increasing metamorphism (Brearley & Jones 1998). Thermoluminescence properties for Rainbow are similar to those shown by Type 3.1–3.2 chondrites, although it is likely that the TL sensitivity of Rainbow reflects terrestrial weathering in addition to parent-body metamorphism. Oxygen isotope analysis shows that Rainbow has a heavier O-isotopic composition than any previously measured CO3 chondrite, but the data fall on the regression line passing through other CO3s (Fig. 6). Previously it has been argued that there was a rough correlation between O-isotopic composition and metamorphic grade for CO3 chondrites (Rubin 1997). However, if Rainbow is subtype 3.1–3.2, as implied by its mineralogy and TL properties, then its O-isotopic composition plots well away from other CO3s of similar metamorphic grade and this correlation is destroyed.

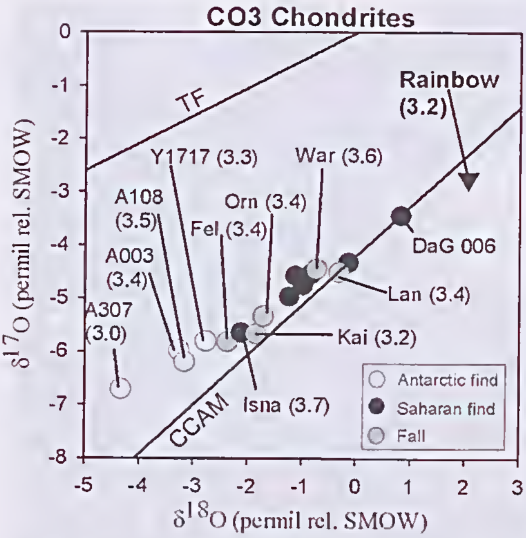

Fig. 6. O-isotopes for Rainbow and other CO3 meteorites (modified slightly from Grossman et al. 2000). *Abbreviations:* TF = terrestrial fractionation line; CCAM = carbonaceous chondrite anhydrous minerals mixing line; SMOV = standard mean ocean water; A003 = Allan Hills (ALH) A77003; A108 = ALH83108; A307 = ALHA77307; DaG006 = Dar al Gani 006; Fel = Felix; Kai = Kainsaz; Lan = Lancé, Orn = Ornans, War = Warrenton; Y1717 = Yamato 791717. Unlabelled Saharan meteorites include Acfer 202 and 243, Dar el Gani 023 and 025, and Hammadah al Hamra 043.

Weathering features shown by Rainbow, such as the prominent iron staining and the almost complete loss of metals and sulphides, indicate it is about W3 on the weathering scale (Wlotzka 1993). Such weathering under the hot dry conditions of the Victorian Mallee may have slightly enriched the heavy O isotopes but probably not sufficiently to maintain the link between isotopic composition and metamorphic grade (Grossman et al. 2000). Based on the evidence to date, the closest CO3 chondrite to Rainbow appears to be Kainsaz (CO3.2), which was seen to fall near Muslyumov, Russia, in 1937 (Grossman et al. 2000).

THE PIGICK METEORITE

Location

Fragments of the meteorite were found scattered randomly in allotments 7A and 8, Parish of Pigick (Fig. 3), with the same geographic coordinates as the Rainbow meteorite. The two larger pieces were found apart from a cluster of the smaller pieces. This distribution suggests there are more stones undiscovered.

Appearance and mineralogy

Like Rainbow, the fragments of the Pigick meteorite are highly weathered in appearance, with a thin limonitic outer crust in which are embedded small quartz grains derived from the surrounding soil. The pieces, with weights ranging from 169 g down to 7.6 g, are irregular in outline and crossed by deeply penetrating cracks (Fig. 1). Despite this weathering, the internal structure is coherent and small grains of bright metallic minerals are visible on polished surfaces.

In thin section, chondrules are reasonably common but usually quite indistinct due to strong recrystallisation. The most obvious chondrules are barred varieties containing olivine, orthopyroxene and plagioclase. They range between about 0.5 and 2 mm across and are set in a recrystallised, highly fractured matrix. The fractures show strong sub-parallel alignment and are filled with iron oxides, which also stain grain boundaries (Fig. 7). These features make it difficult to distinguish between coarser-grained chondrules, individual silicate fragments and coarse grains in the recrystallised matrix. On the weathering scale of Wlotzka (1993), Pigick rates about W3. This is similar to Rainbow, but in the absence of absolute dating no direct conclusion can be drawn from this observation.

Marked undulose extinction is a feature of the larger silicate grains and there is limited development of planar fractures in olivine grains (Fig. 8). These features suggest a level of S3 on the scale of shock metamorphism (Stöffler et al. 1991).

Limited electron microprobe data showed that orthopyroxene compositions are homogeneous, averaging $En_{81.9}Fs_{16.6}Wo_{1.5}$. The CaO contents in the orthopyroxenes are typical of Type 5 chondrites (Scott et al. 1986). Olivine compositions are also quite homogeneous, averaging $Fo_{80.8}Fa_{18.8}Te_{0.4}$. The values of Fa in olivine and Fs in orthopyroxene clearly fall within the field of H chondrites (Brearley & Jones 1998). Clinopyroxene was not detected. The feldspar occurring in chondrules and as a minor matrix component is oligoclase (average $Ab_{78}An_{13}Or_{9}$). Of the metallic minerals, troilite is the most abundant, forming irregular grains up to 0.4 mm across. It is relatively lightly affected by alteration to goethite, unlike the slightly smaller kamacite and taenite grains, which in many places occur as relicts in patches of goethite. The few analyses obtained indicate a range of 35.4–46.9% Ni in taenite and 3.8–6.7% Ni in kamacite.

Fig. 7. Highly fractured texture in the Pigick meteorite. Note the pervasive system of sub-parallel fractures (field of view 3 mm across).

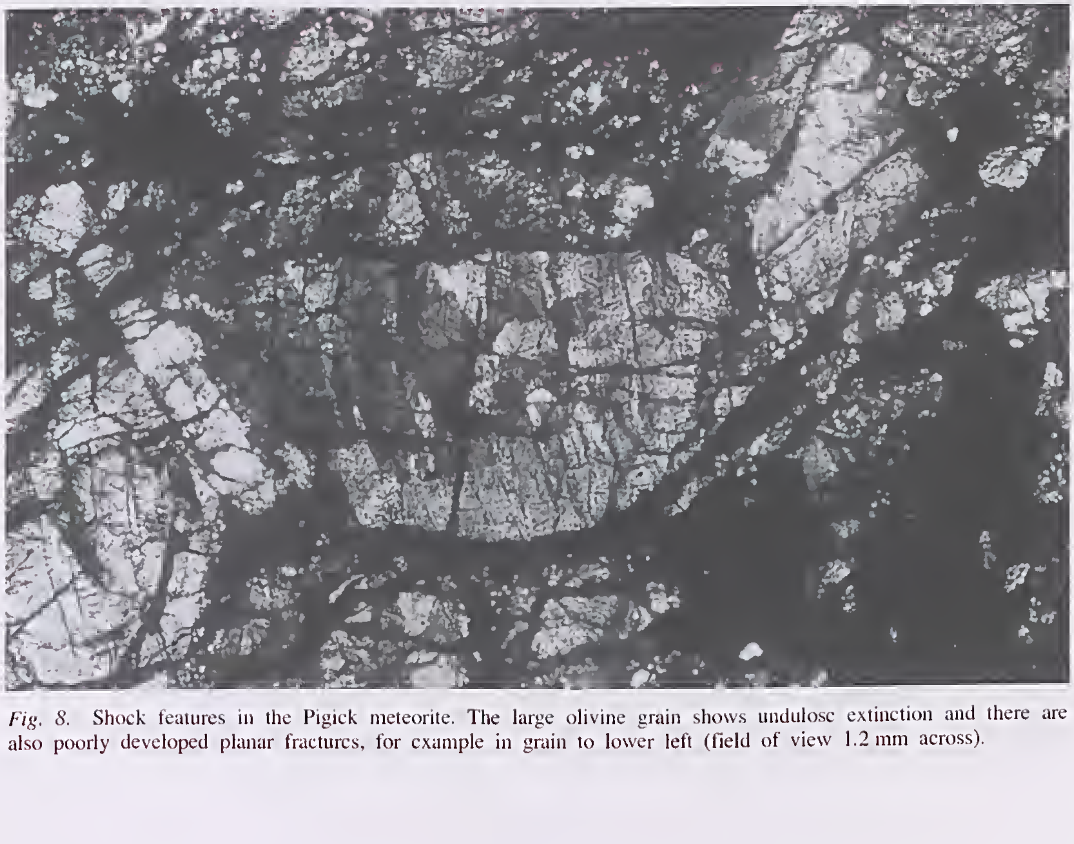

Fig. 8. Shock features in the Pigick meteorite. The large olivine grain shows undulose extinction and there are also poorly developed planar fractures, for example in grain to lower left (field of view 1.2 mm across).

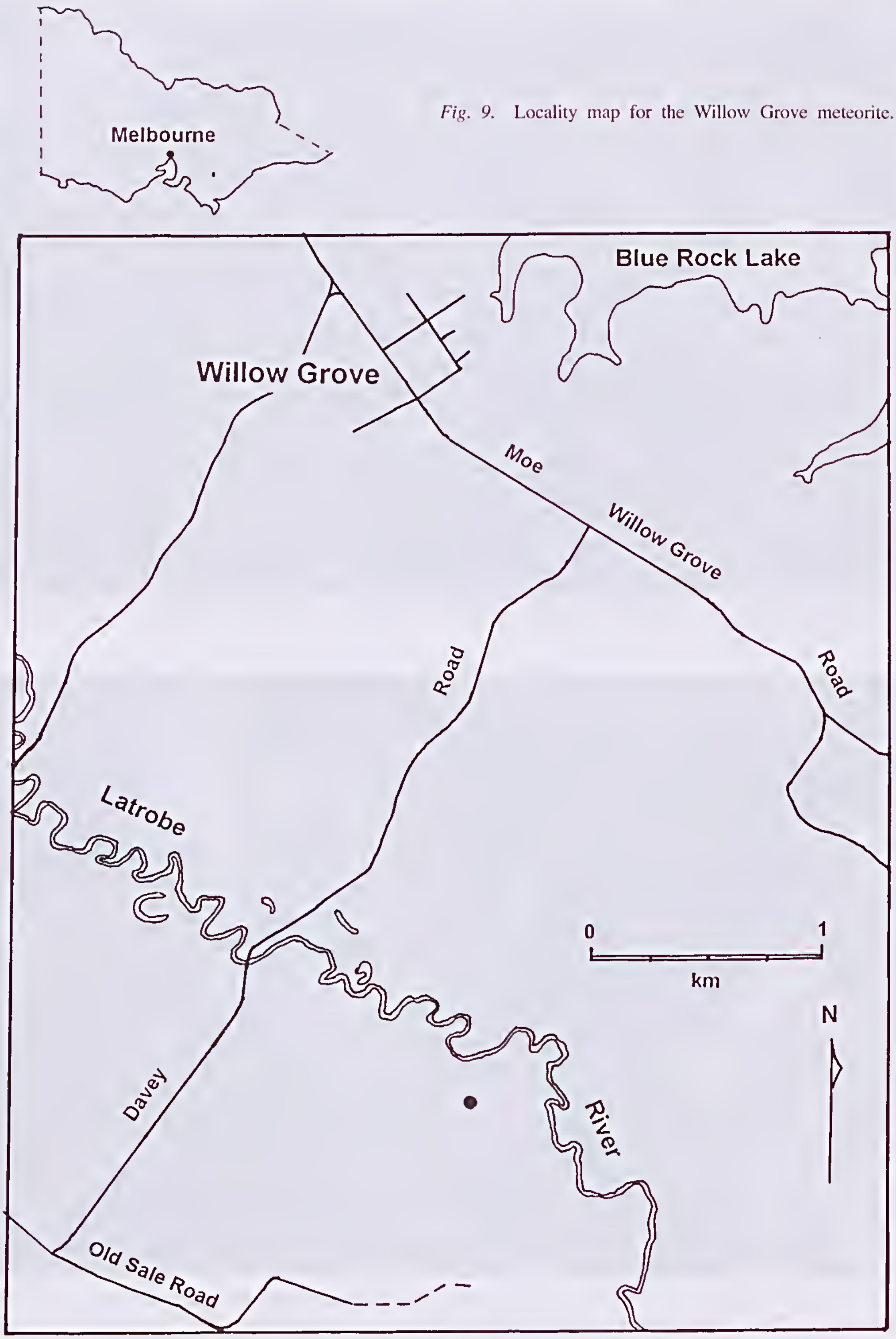

Fig. 9. Locality map for the Willow Grove meteorite.

No bulk chemical data have been obtained on the Pigick meteorite. Nevertheless the mineralogical features and compositions strongly suggest it is an H5 ordinary chondrite showing weak to moderate shock features. Dimboola is the only other H5 meteorite from Victoria, but does not show shock features (Mason 1974).

THE WILLOW GROVE METEORITE

Location

The two pieces of the Willow Grove iron meteorite were found within metres of each other in a paddock on the Buckley farm, off Old Sale Road, between Westbury and Willow Grove (Fig. 9). The site is near the top of the north-west flank of a small knoll overlooking the Latrobe River and has approximate geographic coordinates of 38°6.2′S,146°10.9′E. The high point is capped by a Tertiary conglomerate shedding rounded pebbles of reef quartz and chert into the soil.

Appearance, mineralogy and structure

Both masses are irregular lumps with a thin, dark brown oxidised coating, with no recognisable 'thumb-prints'. The smaller mass is roughly five-sided, measuring approximately 100 × 70 × 70 mm. The larger piece, measuring 160 × 160 × 110 mm, consists of two roughly ovoid masses joined along a neck which may be an incipient fracture. The two masses cannot be fitted together, even allowing for removal of surfaces by oxidation. Bright metal is easily exposed beneath the oxide crust, which X-ray diffraction revealed consists of a mixture of maghemite and reevesite (nickel carbonate), with minor goethite. There are thin scour marks made by the plough on both pieces. Pitting and remelting caused by an oxyacetylene flame are present in several places on the smaller mass (Fig. 2).

A portion of the meteorite was prepared for examination of three orthogonal sections under reflected light microscopy. Etching in 10% nital solution revealed on two of the sections a system of closely spaced tabular features identifiable as lath martensite (Fig. 10). Martensite in Fe–Ni alloys is a body-centred cubic phase resulting from the diffusionless shear and twin-related transformation of the high temperature face-centred cubic phase (austenite) during cooling. The tabular features are between 5 and 20 μm across and can be taken to consist of packets of finer martensite crystals (Krauss & Marder 1971) that are not readily observable in reflected light. The arrangement of these lath packets varies considerably. In the simplest structure only one system of packets dominates, but may be crossed by occasional narrow bands containing a secondary system of lath packets. More complex structures are represented by much higher concentrations of these secondary lath systems. Large numbers of microcracks are present through the sections, in particular near the outer surface of the meteorite. These cracks appear to be filled with the same corrosion product as forms the outer crust and have been attributed to stress corrosion (Birch et al. 2001). The only other phase present is schreibersite, occurring as very rare grains.

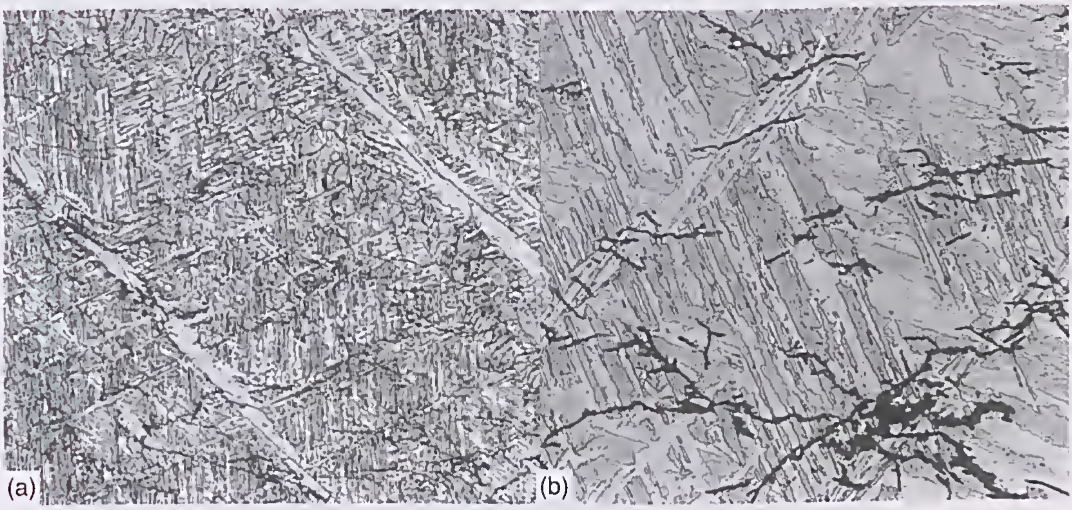

Fig. 10. Typical structures in Willow Grove meteorite. The main feature is lath martensite, forming the plate-like texture, crossed by a network of microcracks [field of view is 1.6 mm across in (a), 0.3 mm across in (b)].

Composition

Chemical analysis by electron microprobe and instrumental neutron activation analysis gave bulk Ni contents between 26.4 and 29.0 wt. %, with an average of 27.9 wt. %. Cobalt contents are between 1.06 and 1.23 wt. %, averaging 1.2 wt. %. The INAA analyses gave similar values for Ni and Co, as well as data for other minor elements such as Ga, As, Ir and Au (see Table 2). Atomic emission spectroscopy showed the carbon content to be 0.15 ± 0.01 wt. % and the phosphorus content to be less than 0.01 wt. %.

Willow Grove has high contents of the refractory elements Re, Ir and Pt, and low contents of the volatile elements Cu, Ga, As and Au. If these are converted to element/Ni ratios, they are much lower than those for any known group of chondritic meteorites. In addition, the W/Ir ratio of Willow Grove is significantly lower than equivalent ratios for metal nodules from ordinary chondrites (Kong et al. 1998).

Comparison with other meteorites

The structure and composition of Willow Grove make it a unique meteorite. Amongst the small number of meteorites with Ni contents between 25 and 35 wt. %, that of Willow Grove is exceeded by Santa Catharina (35%), Tishomingo (32.1%), Twin City (29.9%) and Lime Creek (29.5%). Tishomingo (Buchwald 1975; Ives et al. 1978) and Willow Grove are the only two of these that consist almost entirely of martensite. However, Tishomingo consists of plate martensite (Buchwald 1975), in contrast to the lath martensite of Willow Grove. Studies of laboratory alloys show that martensite generally forms with a lath morphology at low Ni concentrations and with plate morphology at higher Ni concentrations, with the transition occurring in the range 28–30 wt. % (Brofman & Ansell 1982). It therefore appears that the transition in meteorites occurs over a near-identical range of Ni contents, even allowing for the effects of other elements such as Co and C that may affect the transition in opposite ways.

Origin and cooling history

The very low content of volatile elements in Willow Grove, including the low W/Ir ratio, may have been caused by a high-temperature impact in an asteroid setting, that led to out-gassing from a relatively oxidised, possibly chondritic, regolith. On the other hand, depletion in volatile elements could be attributed to inheritance from a chondritic precursor that accreted at very high temperatures (Kelly & Larimer 1977; Scott et al. 1996).

During subsequent cooling, there was enough residual heat to allow the growth of moderately large (> 5 cm) crystals of taenite (= austenite in metallurgical terms). The material continued to cool through the (kamacite + taenite) field to a temperature (the MS temperature) at which the transformation to martensite commenced. Based on an MS temperature of ~ 65°C obtained for a laboratory Fe-27 wt. % Ni alloy austenised at high temperature (Brofman & Ansell 1982), the MS temperature for Willow Grove is likely to have been similar. The absence of kamacite in Willow Grove may be due to the very low schreibersite content, as early-formed schreibersite has been observed to assist the nucleation of kamacite in low-Ni Fe meteorites (Naryan & Goldstein 1984). Alternatively, the cooling rate may have been rapid enough to suppress kamacite nucleation. It is not possible to detect any retained taenite by light microscopy, so it is uncertain whether the transformation to martensite was completed during cooling to the lowest temperature reached in space. Heating accompanying the meteorite's passage through the Earth's atmosphere would not have affected any of the observed features in the interior of the preserved pieces. Once in the weathering environment, the meteorite was subject to stress corrosion by terrestrial fluids, leading to the observed system of microcracks.

CONCLUSIONS

Rainbow and Willow Grove are two highly distinctive and unusual meteorites. They show some properties that are at or beyond the limits

	Cr µg/g	Fe wt.%	Co wt.%	Ni wt.%	Cu µg/g	Ga µg/g	Ge µg/g	As µg/g	W µg/g	Re ng/g	Ir µg/g	Pt µg/g	Au µg/g
*		71.0	1.13	27.5									
+	170		1.21	27.9	10	0.23	< 40	0.783	1.52	2550	17.4	23.7	0.233

Table 2. Chemical analysis of the Willow Grove meteorite. *electron microprobe data (Museum Victoria); + INAA data from J. Wasson (UCLA).

shown by their particular types in the meteorite classification scheme, and hence extend our knowledge of asteroid formation. While a common type, Pigick shows shock features that have not been observed in any other Victorian meteorite. The occurrence of these three meteorites in such a relatively restricted part of the Australian continent should encourage further discoveries.

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TRANSACTIONS

OF THE

ROYAL SOCIETY OF VICTORIA

MT ELEPHANT AND THE BASALT PLAINS: A NATURAL AND SOCIAL HISTORY SEMINAR

Derrinallum and Lismore, western Victoria, 20 October 2001

INTRODUCTION

To further understand this unique volcanic formation, surrounding landscape and cultural history, the Derrinallum Lismore Community Association Inc. conducted an exciting and informative program that included speakers with specialised expertise and extensive local knowledge. They covered such diverse topics as Koori heritage (Vicki Couzens), plains geology (Dr Bill Birch), botany (Tim Barlow) and natural history (James Ross), ornithology (Bob Hughes and Michael Sturmfels), volcanic stone architecture (Prof. Miles Lewis), early settlement (Greg Brinsmead), history (Lawton French), art (Dr Noela Stratford) and future land use (Clive May).

GEOLOGICAL OVERVIEW OF THE WESTERN VICTORIAN VOLCANIC PROVINCE

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The extensive late Cainozoic lava plains of western Victoria form part of the intraplate basaltic province extending along the eastern Australian margin. The western Victorian lava field contains a diverse array of features associated with both effusive and explosive eruption styles, including lava shields, scoria cones and maars, with their associated deposits. These features commonly show well-preserved evidence for the mechanisms of eruption and emplacement. As well as their importance for vulcanology, the lava plains have considerable cultural, environmental and economic significance.

DESPITE the popular misconception that there are no volcanoes in Australia, young volcanic rocks form a discontinuous belt stretching for over 4000 km from Tasmania to northern Queensland. This belt represents one of the world's great basaltic provinces, in extent if not in volume. This volcanic activity began about 70 million years ago and has sputtered away almost to the present day in some regions. The activity is in some way associated with the opening of the Southern Ocean and the Tasman Sea and the continued northward movement of the Australian continent. It is known as 'intraplate' volcanism, because the volcanic belt is a long way from the active margins of the tectonic plate on which Australia sits (Johnson 1989).

The volcanic plains of western Victoria began forming about 4.5 million years ago and since then about 1300 km^3 of lava have been erupted, over an area of about 15 000 km^2. A simple calculation gives an average thickness of about 80 m. Over 400 eruption points have been mapped but it is likely there are many more (Fig. 1).

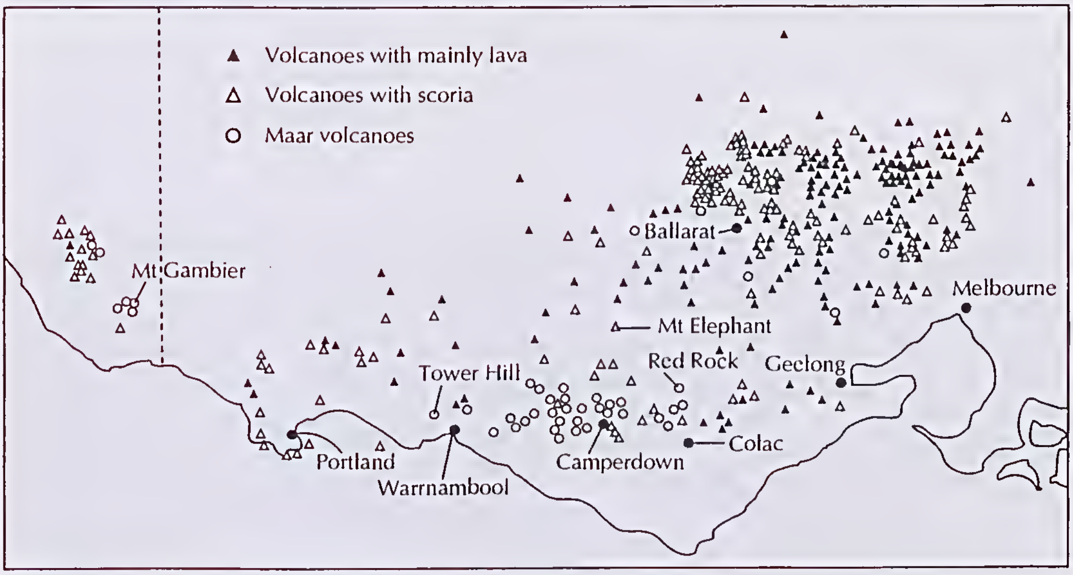

Fig. 1. Eruption point distribution on the western Victorian lava plains.

Recognition of the rich array of volcanic features on the plain by Europeans began in 1836, with Major Thomas Mitchell's observations at the summit crater of Mt Napier, now thought to be the youngest volcano in Victoria. By the 1840s, knowledge of the extent of the lavas was well known. Formal geological mapping of the region began in the 1850s, although the precise age of the volcanic rocks had to await development of modern dating methods in the late 20th Century. Although there are still doubts associated with age estimates for the youngest eruptions, it is generally accepted that these took place between only thousands, or a few tens of thousands, of years ago.

The lava flows are mainly basaltic, with most of the magmas derived by partial melting in the mantle and modified by crystal fractionation during their rise to the surface (Price et al. 1997).

PHYSICAL VOLCANOLOGY

A simplified classification divides the eruption points in the province into three types; lava shields generally representing older effusive activity, and scoria cones and maars resulting from more recent explosive activity. In practice, many centres are combinations of both types of activity and have complex histories, so that more detailed classification schemes are required (Rosengren 1994).

Effusive eruptions

The western Victorian lava field is an example of a plains-basalt province. It has been built up by many small-volume flows from either fissures or from lava shield volcanoes. There are numerous examples of shield volcanoes on the plain, although they are generally not prominent features because of their low-angle sides. Some examples include Mt Pierrepoint, Mt Cotterell, Mt Ridley and the base of Mt Napier (Fig. 2). Mt Hamilton is a fine example of a broad lava cone with a summit crater. It can be assumed that eruptions from most of these volcanoes were relatively non-explosive. Lava flows spread out over the surrounding country, in some cases, such as the flows from Mt Eccles, Mt Rouse and Mt Napier, exploiting stream valleys for distances of up to 50 or 60 km. Typically, these are very fluid, fast-moving 'pahoehoe' or ropy lava flows.

Fig. 2. Mt Napier, showing the older broad low lava shield.

Features of these flows are best seen in young examples. So-called 'stony rises' around Mt Rouse and Mt Porndon are hummocky surfaces caused by uneven collapse of partially cooled lava or by pressure ridging. Lava flows may develop levee banks due to cooling at the edges so that, when the supply of fresh lava ceases, a well-defined channel or canal, seen for example at Mt Eccles, remains. Lava flowing in a tunnel beneath a solid roof layer may drain away, leaving a tube or cave. The Byaduk caves on the Harman Valley flow from Mt Napier are fine examples. Tumuli are domes or blisters on the surface of lava flows, possibly caused by localised concentrations of gas, with examples seen on the Harman Valley flow at Wallacedale. Columnar jointing is produced by progressive cooling and contraction of lava flows and is a widespread feature in western and central Victoria. Pillow textures, formed when lava flows slowly into water, are rare in the province, but can be seen near Exford.

Explosive eruptions

There are two main types of explosive eruption centres in the western Victorian province. The most conspicuous of these are steep-sided cones of scoria with one or more summit craters. These typically result from a single phase of Strombolian-type eruptions, which may have lasted from a few months to several years. The cones may reach several hundred metres high and exceed a kilometre in diameter. Mt Elephant, at Derrinallum, is the largest scoria cone in Victoria, reaching 240 m high and 1.3 km across its base, and appears to have formed by near-continuous eruption (Fig. 3). Other examples include Mt Franklin near Daylesford and Mt Holden near Beveridge. Further away from the vent, sheet-like, bedded deposits of scoria and ash may accumulate. Good examples are exposed in quarries at the Mt Leura and Red Rocks centres. Spindle-shaped bombs and irregular blocks flung from the crater are common. At some scoria cones, Hawaiian-type eruptions, in the form of fire-fountains of lava, may produce spatter, which can build up to form a rampart around the crater. The rim of the Mt Napier crater is a good example of a spatter ridge. Many scoria cones had their crater rims breached by small lava flows late in their eruptive history.

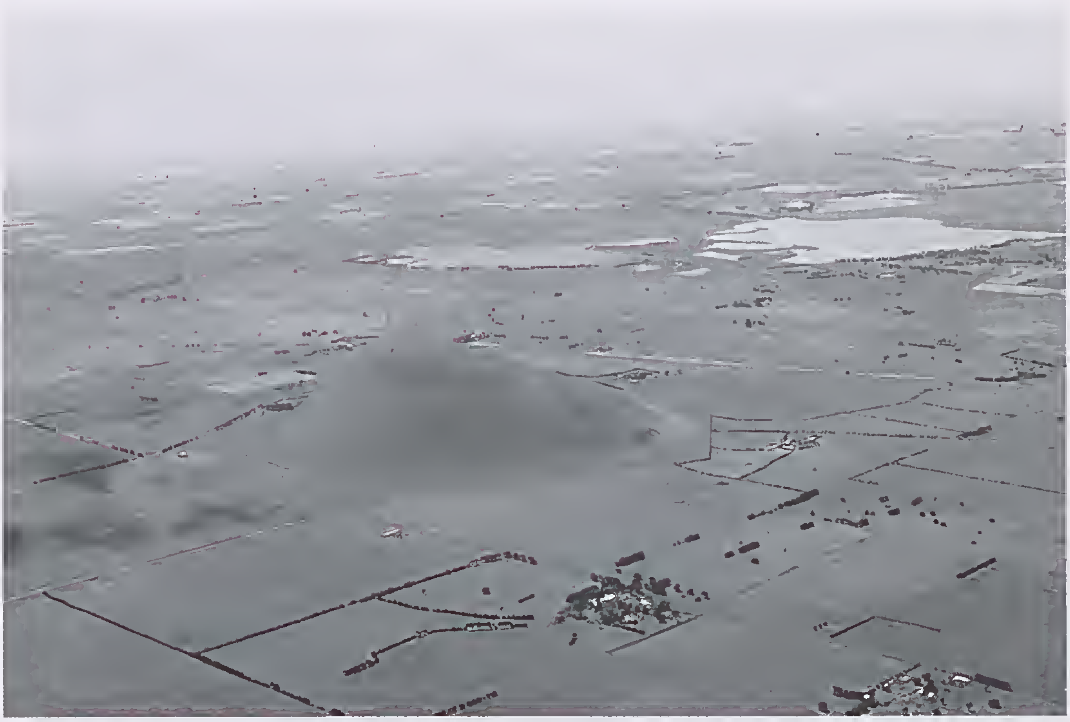

Fig. 3. Mt Elephant.

The more subdued features arising from explosive eruptions are wide shallow craters known as maars and tuff rings. These result from the blast caused by interaction of rising magma and near-surface water, either as ground water in porous rocks or as lakes. These phreatomagmatic craters are commonly below the ground surface and filled by a lake. Around the margin is a low rim consisting of beds of ash and lapilli, showing textures resulting from air-fall and base-surge processes. A blanket of ash from the eruptions may also be spread over the region surrounding the crater. Maars are widespread in the southern half of the province, with about 40 known. They can be discrete centres, such as Lake Purrumbeet and Lake Keilambeet (Fig. 4), or in complexes, such as at Red Rock and Mt Leura. Lake Bullenmerri near Camperdown is a coalescence of three maar craters. Strombolian-type eruptions that build scoria cones may also be associated with maars, with a fine example represented by the Tower Hill complex near Warrnambool. Small lava flows may also be present.

Composite eruptions

Many of the most prominent volcanoes experienced several distinct phases of eruption, involving both effusive and explosive events. The Mt Leura and Mt Noorat complexes, for example, consist of nested scoria cones on a nearly buried maar or tuff ring (Fig. 5). Activity at Mt Napier began as lava eruptions building a low shield volcano, but climaxed as a cluster of scoria and spatter cones. In the central highlands near Ballarat, and in the Gisborne–Sunbury region north of Melbourne, many volcanoes are mixtures of scoria and lava flows. Examples include Mt Kooroocheang, Mt Buninyong and Mt Aitken.

SIGNIFICANCE OF THE VOLCANIC FEATURES

There are many reasons to value the volcanic features of western Victoria, stemming from their scientific, cultural and economic significance. They have inspired a great many important geological studies, covering the petrology, geochemistry and

Fig. 4. Lake Keilambeet.

geochronology of the volcanic rocks and their inclusions (eg. Irving & Green 1976; O'Reilly et al. 1988; Price et al. 1997); the geomorphology of the region (eg. Ollier & Joyce 1964) and the palaeo-environmental record preserved in maar sediments (eg. Jones et al. 2001). They are also widely used for teaching of volcanic geology.

Significant scientific aspects of the volcanism may be summarised as follows:

- Well-preserved features of a diverse variety of eruption types are typical of a major intraplate basaltic province.
- Evidence is provided for the causes and timing of volcanism in eastern Australia, especially in relation to the movement of the Australian plate over irregularities in the mantle.
- Xenolith and megacryst assemblages found at many explosive eruption points reveal the nature of metamorphic and magmatic processes in the deep crust and mantle.
- The ranges in age and degree of weathering enable the modelling of regolith and landform development over time.
- Sediments in maar lakes preserve records of palaeoclimates in the region over the past 5–10 thousand years.

The lava plains are also significant for cultural, educational and economic reasons. Some of the more important aspects can be summarised as follows:

- Aboriginal people in the region may have witnessed some of the youngest eruptions and there are some sites that continue to have cultural and spiritual significance.
- Agricultural production has benefited from the rich soils derived by the weathering of basaltic flows and associated pyroclastic deposits.
- Hard rock from lava flows and unconsolidated scoria and tuff deposits are significant resources.
- The region has considerable potential for ecotourism (for example, the recent development of the Volcanoes Discovery Trail).

There is considerable scope for more detailed research in many of these aspects. For example, in some parts of the region the volcanic features remain poorly characterised. In order to enable the continuation of these studies and to maximise the economic potential of the region, high standards of conservation and preservation must be developed and implemented.

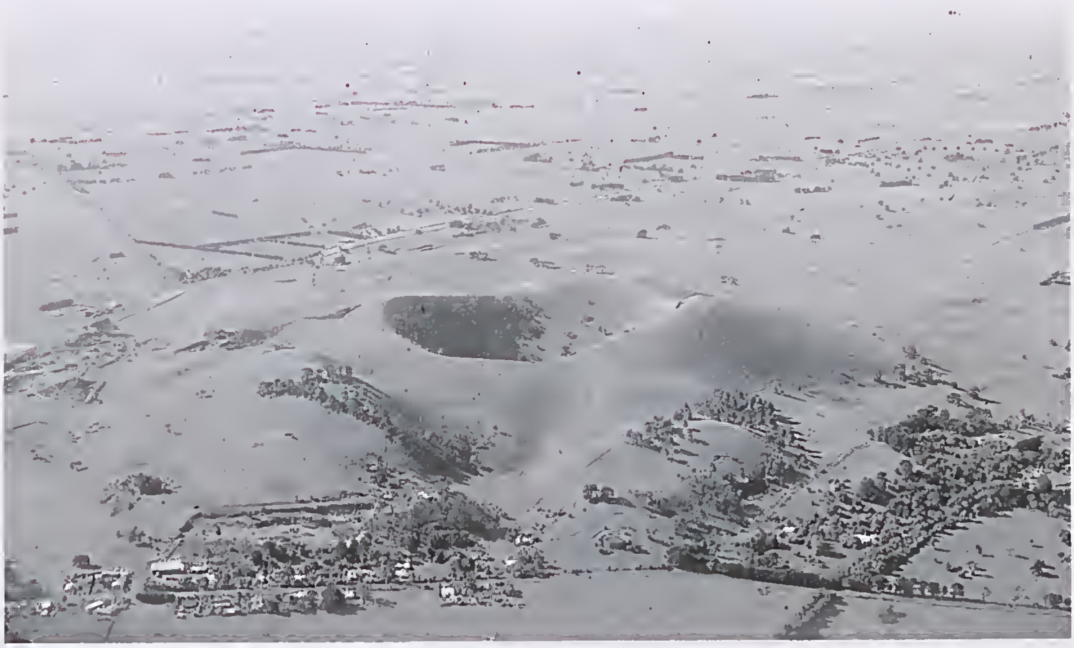

Fig. 5. Mt Noorat with summit crater.

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VEGETATION OF THE VICTORIAN VOLCANIC PLAIN

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The Victorian Volcanic Plain is generally perceived as being an homogenous, open, treeless landscape. In fact the region formerly supported a complex mosaic of vegetation communities including grasslands, wetlands, woodlands and forests based on equally diverse physical environments. This paper describes some of the main vegetation types that occurred on the Volcanic Plain particularly from the Mt Elephant region. Many of these communities are now so depleted in nature that their previous composition can only be surmised from small degraded remnants. Conservation of these remnants is crucial to our future ability to recreate, restore and manage natural ecosystems within sustainable agricultural landscapes.

COMMON perception would have us believe that western Victoria is one vast, treeless volcanic plain extending from the Plenty River to the South Australian border.

Such a view is entirely false: rather 'it' is comprised of a number of geological formations and foundations, supports an immense array of vegetation types (a few of which are naturally treeless), and whilst the eastern boundary is reasonably clear (being defined by the Plenty River for the most part), the southern, northern and particularly western, boundaries, are distinct only on maps where the boundaries have been inked in.

We adopt the definition of Conn (1993) to define the region—the Victorian Volcanic Plain—a definition that is now widely accepted and forms the basis for delineating the 'western plains' for much scientific and conservation planning activity at regional, State and National levels. Conn wisely drew upon earlier works, the collective wisdom of which was brought together in the 1964 Proceedings of the Royal Society of Victoria, and to which we also refer you for the authoritative accounts of the physical and biological environment (eg. Willis 1964). The extent of the Victorian Volcanic Plain is shown in Fig. 1.

Fig. 1. The Victorian Volcanic Plain Bioregion.

LANDSCAPE

The principle geology of the Victorian Volcanic Plain is Quaternery Basalt, largely generated during the Upper Cainozoic era. Interspersed amongst the basalt are geological remnants that precede and survive the period of vulcanism that produced the 'Plain'.

Thus, around Lismore we have soils derived from granites that are connected to the geology of Mt Emu. Around Chatsworth, Silurian and Devonian sandstone exists as an outlier of both the Grampians and the Great Dividing Range. Similar can be seen around Rokewood. On the margins of the Plain, gravel outwash and wind-blown sand, together with a thin mantle of basalt, produce complex physical environments supporting similarly complex and sometimes confusing vegetation patterns.

If the Victorian Volcanic Plain is not characterised by its flatness, then it is by the volcanic eruption points. Their eminence on the horizon inspired the imagination of both the original Koori people and subsequent surveyors and squatters. Whilst some have retained the original Koori name (Mt Weejort, Mt Noorat, Mt Warrenheip et al.), many have been renamed after what, we suspect, was the state of mind of the surveyor at the time. Thus some bear the moniker of surveyors' supervisors (Mt Bainbridge), their wives (Mt Rebecca), native wildlife (Mt Emu), or the fauna of distant continents (Mt Elephant). Occasionally, the results of prolonged isolation and unsated desire are invoked, as is presumably the case for the naming of the Mammaloid Hills around Learmonth.

VEGETATION

Western Victoria most certainly was not treeless at the time of European occupation, although there were discrete areas that were effectively devoid of trees. Early surveyors remarked on this aspect of the plains to the west of Port Phillip Bay (Laverton/Sunshine/Keilor) and around Cressy.

It is apparent from an examination of early surveyors' maps that treeless areas occurred as discrete 'openings' in the landscape. Invariably, these openings were named as a plain of some sort (Karabeal Plain, Keilor Plain etc.). These plains ranged in size from a couple of hundred hectares to many tens of thousands of hectares, and formed the basis of the first sheep runs.

These plains were the true grasslands. Exactly why they were 'treeless' has been the subject of on-going, but low-level, debate amongst both professional botanists and other experienced observers of the land. Without exploring this debate in detail, we suggest that the causes and influences of treelessness are multiple, compounding and variable. Chief amongst them are primarily 'heavy' clay soils that are poorly drained, readily becoming waterlogged or exceedingly dry, and, to a lesser extent, lower rainfall and frequency of burning. It is notable that the clay soils are, in an Australian context, relatively well-endowed with nutrients, especially available phosphorous.

One should be wary of the claim that relatively low rainfall alone is the cause of 'treelessness' (eg. Commonwealth and Victorian RFA Steering Committee 2000). The drier parts of the Plains (around Melton) in fact support woody vegetation—Grey Box grassy woodland. Soil type and its drainage characteristics appear to be the primary determinants of grassland occurrence.

Some forty-eight Ecological Vegetation Classes (EVCs) have been identified as occurring on the Victorian Volcanic Plain, either by direct observation or ecological modelling (Commonwealth and Victorian RFA Steering Committee 2000). An EVC is comprised of one or more plant communities that consistently occur within a defined environment. Examples include Scoria Cone Woodland and Stony Rise Woodland. Both EVCs are relatively similar based on floristics alone, but nevertheless occur in distinct environments. Detailed descriptions of the relevant EVCs are given in the West Victoria Comprehensive Regional Assessment Biodiversity Assessment (Commonwealth and Victorian RFA Steering Committee 2000).

Depending on the moisture regime, the grasslands were dominated by Kangaroo Grass (*Themeda triandra*), or (at the wetter end of the scale) Silver Tussock (*Poa labillardierei*). The characteristic feature structurally is the tussock life-form. This life-form (as opposed to a turf-like habit) is conducive to a rich flora that is able to occupy the inter-tussock gaps. It is here that grow the wealth of lilies, orchids, sedges, herbs and small shrubs that give good quality grasslands (ie. those that are floristically rich) their floriferous display from early spring to mid-summer.

There are few sharp vegetational transitions on the Volcanic Plains. Just as Kangaroo Grass dominated communities grade into Silver Tussock communities, so too does the latter grade into swamps dominated by Swamp Wallaby-grass (*Amphibromus nervosus*), Cane Grass (*Eragrostis infecunda*) or Sweet Grass (*Glyceria australis*). Swamps may also be effectively devoid of grasses, and instead be dominated by a range of moisture-loving herbs and/or sedges, or even shrubs such as Woolly tea-tree (*Leptospermum lanigerum*).

Where soil drainage improves, such as on the edges of lava flows and craters where basalt boulders are exposed, or on scoria cones such as Mt Elephant and Mt Anakie, woody vegetation becomes more dominant. Shrublands dominated by Tree Violet (*Hymenanthera dentata*) or Blackwood (*Acacia melanoxylon*) are still a familiar site on stony rises. What has been completely exterminated, virtually to the last tree, are the Honeysuckle (*Banksia marginata*)–Sheoak (*Allocasuarina verticillata*)–Lightwood (*Acacia implexa*) woodlands that were so regularly commented upon by early explorers and settlers.

It is likely that Mt Elephant supported Honeysuckle-dominated woodland at the time of European settlement. The relevant EVC is defined as 'Scoria Cone Woodland'. This woodland community is dominated by Honeysuckle or Silver Banksia [*Banksia marginata* (tree-form)] and Drooping Sheoak (*Allocasuarina verticillata*). Manna Gum (*Eucalyptus viminalis*), Blackwood (*Acacia melanoxylon*) and Lightwood (*A. implexa*) may also be present, along with smaller shrubs such as Tree Violet (*Hymenanthera dentata*) and Sweet Bursaria (*Bursaria spinosa*). This EVC may well have occurred more extensively to the south of Mt Elephant in the Cloven Hills area.

To the south-east of Mt Elephant occurs Stony Rise Woodland dominated by similar species as that found on Scoria Cone Woodland, but distinguished by geological and geomorphological differences (reduced drainage and greater frequency of basalt rock). This EVC is extensive in the Stony Rise country to the north of Mt Elephant, around Vite Vite and extending north to Skipton.

Swamp Scrub, dominated by Woolly Tea-tree (*Leptospermum lanigerum*) but otherwise poorly known floristically, occurred in the swales between stony rises where drainage (both surface and subsurface) is impeded. These Swamp Scrubs may have been restricted to areas where local springs provided permanently wet conditions, such as in the Lake Bookaar area.

Small wetlands of either a grassy or sedgey nature (depending on the degree of inundation) occurred extensively on the plains to the west of Mt Elephant where heavy clays provide impeded drainage and potentially a high degree of moisture stress during summer. These wetlands occurred as a mosaic amongst a landscape dominated by Plains Grassland, dominated by Kangaroo Grass (*Themeda triandra*).

Granitic and lateritic soils, as occurs in discrete components around Lismore, would have supported Grassy Woodland, with Honeysuckle and Drooping Sheoak once again dominating due to improved drainage characteristics. River Red Gum (*Eucalyptus camaldulensis*), Swamp Gum (*E. ovata*), and particularly Manna Gum (*E. viminalis*) may have also been present on these better-drained areas.

It is probable that the Scoria Cone Woodlands and Plains Grassy Woodlands were the most species-rich of the plant communities found in the immediate vicinity of Mt Elephant. No examples remain that are in any way intact.

Taller forests developed on well-drained, higher rainfall areas towards the coast (particularly in the south-west) and the north around Ballarat. These were dominated by Manna Gum, Messmate (*Eucalyptus obliqua*) and occasionally Narrow-leaf Peppermint (*E. radiata*). Undoubtedly, these forests provided the bulk of the timber required for the establishment of European occupation, and it is because of this utility that many areas have been retained and managed for this purpose.

The audience will be familiar with existing stands of magnificent specimens of River Red Gum, widely spaced in a woodland formation giving a park-like appearance to the landscape that so enraptured early observers such as Thomas Mitchell. Unfortunately, what we see today around Dunkeld and Buangor is the mere skeleton. Completely devoured is the grassy, nutritious understorey that inspired the Australia Felix comment. Even more worrying is the fact that these trees all pre-date European occupation. There has not been, and will not be without deliberate and sustained management, any replacement of these trees, and it is possible these Red Gum woodlands will go the same way as the Honeysuckle woodlands.

CONSERVATION STATUS

There have been several attempts at determining the current extent of native vegetation communities across the Volcanic Plain (eg. NRE 1997; Table 1). The results of these must be treated with caution as they are be-devilled with incomplete survey information and the difficulty in determining what constitutes a 'native vegetation' community within the continuum of disturbance, degradation and fragmentation that has undoubtedly occurred within most vegetation types.

Greater than 95% of all native vegetation has been cleared from the Victorian Volcanic Plain (see Table 1). Only Heathy Woodlands and Lowland Forests (30%), and some wetland types still occupy a substantial proportion of their former distribution. Less than 1% of the original distribution of Plains Grassland and Grassy Woodland communities remain in the region. In addition seasonal wetlands such as deep freshwater marshes and freshwater meadows have also been significantly reduced in number, size and quality because of agricultural practices associated with draining, clearing, cropping and grazing.

The area of open grassland naturally occurring across the Volcanic Plain was probably of the order of 800 000–1 000 000 ha (McDougall et al. 1992, 1994; NRE 1997). It is likely that something of the order of 0.5% of that area remains as native grassland today. The oft-quoted figure of 0.16% (Stuwe 1986) has been wrongly ascribed as the area of original native grassland remaining on the western plains. In fact this figure merely represents the area of sites identified in this one survey as a percentage of the total area of the volcanic plain. A more complete estimate of the area of native grassland remaining based on the compilation of a number of surveys and reports is likely to be of the order of 5000–6000 ha (Barlow 1999; Ross unpub. data). Even this estimate must be qualified as much of this area constitutes degraded or simplified native grassland or disclimax grassy woodland communities and a number of areas (both small and relatively large) have been damaged or destroyed in the past decade. Remnants that are species-rich and with a small weed component would account for less than 1000 ha of this total.

Although so little remains of the natural vegetation of the volcanic plain, the decline in both quantity and quality continues today. This decline can be obvious and dramatic through the destruction of natural vegetation for roadworks, urban development and cropping, or insidious through reduced species richness or diversity as a result of changes to and lack of management or by weed invasion.

	Pre-1750 (ha)	Current (ha)	(%)
Typical and major BVTs			
Grassland complexes	826 402	1 671	0.2
Plains grassy woodland complexes	624 843	5 840	0.9
Herb-rich woodland complexes	304 265	23 005	7.6
Lowland forest complexes	173 463	51 862	29.9
Swamp scrub complexes	57 173	1 007	1.8
Marginal and minor BVTs			
Coastal scrubs and grasslands	2 133	0	0.0
Heathy woodland complexes	1 225	707	57.7
Inland slopes woodland complexes	1 024	0	0.0
Dry foothill forest complexes	10 941	72	0.7
Valley grassy forest complexes	1 375	0	0.0
Riverine grassy woodland complexes	26 989	0	0.0
Riparian forest complexes	818	0	0.0
Total	2 058 910	84 163	4.0
Wetlands and wetland vegetation	153 901	92 034	59.8
Total VVP	2 212 811	176 197	7.9

Table 1. Estimated extent of broad vegetation types of the Victorian Volcanic Plain Bioregion (NRE 1997).

The small size of many remnants and the small populations of many threatened species that survive within them requires us to be both vigilant and pro-active in their conservation. From a biodiversity conservation approach, the modifications in structure and composition undergone by native vegetation communities are not particularly relevant in relation to the need to reverse the current trend of genetic depletion. Without these remnants our future ability to recreate, restore and manage natural ecosystems within sustainable agricultural landscapes will be considerably reduced.

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ARCHITECTURE OF THE BASALT PLAINS

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The architecture of the Western District of Victoria is characterised by the use of basalt. This paper shows that basalt was effectively used for less than half a century—very little before 1853 and scarcely at all after 1901. Almost nothing survives of the mainly timber architecture of the 1840s, but it is known from contemporary watercolors which, unusually, include even the interiors of houses. Before 1847 there was probably some use of basalt in dry walling and in rubble construction, but in the absence of tenure there was a strong disincentive to investment in substantial buildings. The introduction of squatting leases in 1847 gave slightly more security and resulted in some more substantial buildings, including the use of squared honeycomb rock found on the ground surface; a few of these survive. The availability of freehold land from 1853 under the pre-emptive right system resulted in the establishment of the first true quarries and the construction of the first substantial stone houses, though a large proportion of those discussed date from after the cancellation of the leases, generally *c.* 1870. The majority of the designs were conservative, even when produced by sophisticated urban architects. Finally, in the 1890s, there was a battle between the traditional and practical bluestone and the now fashionable red brick, and a number of interesting compromises were effected, before basalt was finally abandoned at the turn of the century.

THE PARAMETERS

In celebrating the public acquisition of Mt Elephant, one of the extinct or dormant volcanoes of the basalt plains, it is quite appropriate that we should consider the architecture of this region, largely built from the lava of these volcanoes. But inevitably we must begin by asking ourselves some basic questions:

- Is basalt in fact the earliest or the most dominant construction material of the region?
- Is this the only area in Australia, or in the world, in which basalt has such a strong role in architecture?
- Does basalt architecture have any distinctive characteristics, other than the material itself?

In addressing the second question, I can only say that in Australia there are no other such regions of basalt architecture. The basalt plains extend from Footscray to somewhere above Portland (not quite so far as the volcanic region itself), though I will concentrate mainly on an area closer to Mt Elephant. There are pockets of basalt, and of basalt architecture, in New South Wales and northern Tasmania, and the South Australians have a stone which they impertinently call 'bluestone' —our word for basalt—but which is an entirely different material. But there is no other extensive region of basalt construction.

Overseas there are areas where tufa or pozzuolana are used, as on Santorini, but I know of only one substantial basalt region, in southern Syria. It is surprising to find classical buildings, like the amphitheatre at Bosra, built in our familiar bluestone, but even more surprising is the fact that Roman period basalt houses, at Shaqqa in the same region, are still inhabited. I know of no other place where Roman buildings are still lived in today, and it should greatly encourage the owners of Western District houses to know that they are so durable.

BEFORE GOLD

I now turn to my other questions. The next question was whether basalt is in fact the earliest or the most dominant construction material of the region, and the answer is not what one might expect. Contrary to popular belief, there was no serious basalt building before 1853. So often people will find that a squatting run was taken up at a certain date and assume that the oldest building on the site dates from that time, but nothing could be further from the truth.

Investment and land tenure

It's necessary to think about the real position of the squatters. At first they held their runs under licence, renewable annually, and could be dispossessed by the Crown lands commissioner on the slightest pretext. From 1847 they could obtain leases, typically of 14 years (eight years in the 'intermediate districts'), and had more security. Nevertheless, if the government chose to survey

and sell a town on their run, of if gold miners entered it, they received no compensation.

From 1847 they were also able to apply for the freehold tenure of a homestead site, or their 'improvements' within the bounds of the run, totalling one square mile or 640 acres (in units of 160 acres). This was called a pre-emptive right, because it could be bought before any public sale took place, at a set price of £1 per acre. But although this provision appeared in 1847, it was politically unpopular, and the government delayed action on it until 1853, when the first pre-emptive rights were sold.

Of course, even before 1847, people would pile up loose stones to make dry stone walls and primitive huts, but they did not build proper stone buildings, because they did not own the land and they couldn't take the risk. There is one documented exception known to me. There is clear evidence that the Manifold brothers were building a stone house at 'Purrumbete' in 1846 (Goodman 1892: 87).

After 1847 there were some buildings of basalt floaters, and even of squared honeycomb basalt found on the surface, but even these were a minority, and there were certainly no proper quarries and no dressed stone buildings. The old bluestone homestead at 'Murdeduke' has been claimed to date from the late 1840s (Curtis 1969: 7.2–7.3), and it has also been claimed that the rubble homestead of the Dennis brothers at 'Tarndtwarncoort', of one storey plus an attic, was built in 1848 (Willingham 1980: 21). There were also brick buildings, such as the second stage of the homestead at 'Wormbete', believed to date from about 1848 (Curtis 1969: 5.4–5.5).

However, I know of no reliably documented bluestone house of any pretension actually surviving from before 1853. In fact, most of those I will mention date from after the cancellation of the squatting licences, when all the land was freehold and when new runs were often created after subdivision of the property, generally towards 1870 (as at 'Gnarpurt', 'Larra' and 'Titanga').

Illustrative evidence

An epitome of the squatter's architecture is provided by Duncan Elphinstone Cooper, whose sketchbook illustrates the tent in which he first occupied his run 'Challicum' at Fiery Creek (Beaufort), on 1 January 1842; then his first hut, built a little later, then his second hut of 1843, and finally his third 'hut'—seemingly a very presentable cottage (though not of bluestone)—of 1845 [Cooper, various dates (unpaginated)].

Our best sources of information on the early period are the watercolors of Charles Norton, now in the State Library of Victoria. Norton reached Melbourne with his father in December 1842, soon afterwards settled on a run at Cardinia Creek (with Terence O'Connor and Hayes). Then, in 1844, aged 18, took out his own pastoral licence (Downer & Phipps 1992: 1). He first illustrates the 'Seven Hills' station of one of the Birch brothers, where he stayed for a time in 1844. Arthur and Cecil Birch were cousins on his mother's side. He includes a detailed view of 'Mr Birche's [*sic*] old hut', which has a bark roof (Fig. 1).

Norton also illustrates the interior of Birch's hut, one of the earliest such images we have, and showing a degree of makeshift comfort—a table with a blue cloth, a sofa down one side and a bench down the other, and various items, including a rifle, two pistols and a saddle, hung selfconsciously on the walls. Interior illustrations from this period are so rare that Nortons are of exceptional interest. His other interiors include his room at his own run, 'Tooralle' (apparently also called 'Tourelle'), and the interior of his homestead on his next property, 'Carlsbadt', in 1847'.

The room at 'Tooralle' still lacks a ceiling, for the underside of the bark roof is visible, but it has what may be a glazed window—a luxury in the country at this time. There is a comfortable-looking bed, some sort of folding stool, a storage chest, a small occasional table, and again a range of items, both functional and decorative—including two rifles and four framed pictures—hanging on the walls. The room at 'Carlsbadt' is the height of sophistication, with a coved ceiling, glazed window, curtained pelmet, chimneypiece, built-in shelves and sophisticated furniture, including an upholstered chaise longue. Most remarkable, however, and quite unexplained, is a group of painted figures on one wall, striking what may be athletic poses.

Norton had been unsuccessful at 'Tooralle' and the run was absorbed into William Cameron's 'Tooral' in the later 1840s (Downer & Phipps 1992: 2). 'Carlsbadt' was Norton's second run, to which he moved in 1847 following his marriage to Susan Meade, and the couple remained until 1850, when they moved to Melbourne. Thus the interior shows some progress towards the comfort appropriate to a family home.

The bark roof

Norton's view of Birch's bark-roofed hut is possibly his most important work. The manner of roofing in bark is distinctively Australian, and though one

does not particularly associate it with the Western District, this is one of the earliest illustrations of a bark roof in Victoria. Bark roofing was scarcely used by Europeans in New South Wales until the 1820s, and then mainly for primitive lean-tos and V-shaped huts. The canonical Australian bark roof seems to have emerged in about 1840, and in the Port Phillip District at the same time as elsewhere.

Stringybark was the most common species used. A sheet would be stripped from the tree by cutting two rings around the trunk, joining them with a vertical cut, and from this cut prising off a large rectangular sheet. The sheet would be flattened and cured by soaking it in water or smoking over a fire, but even so it would shrink and curl when exposed to the weather. It could not be nailed to the roof frame (except perhaps with a single nail per sheet) because it would tear at the nails as it shrank. Instead, it was lashed down with a cord made from the bark itself, or, better still, from greenhide, which has some elasticity.

To stop it curling, logs were rested over it, transverse to the roof slope. But these could not be fixed through the bark, for the same reasons, so they were supported from above. They were pegged or lashed to lighter saplings which were placed on top of them, running up the slope of the roof. These saplings, in turn, were pegged or lashed to each other where they crossed at the apex. Thus, there was a complete frame resting over the roof, but held only by gravity, and not fixed through the bark.

There are some related roofing forms overseas, but they are generally fairly obscure, and it is a moot point whether the Australian version evolved independently. The first reasonably detailed account of a local bark roof is by R. H. Bunbury in 1842: 'the roof is put on with a single nail in each piece of bark, a frame of saplings goes over the whole to prevent the bark from being blown up'. He provides a crude sketch of this (Bunbury 1842, unpaginated). Later, in 1844, Bunbury sketched the buildings on his 'Barton' run, two of which were bark roofed. One or both may have been built by Thomas and Andrew Chirnside about two years earlier, when this formed part of their 'Mt William' run (Ronald 1978: 24–25).

Robert Russell's sketch of whalers' huts at Refuge Cove in 1843, appears to show the developed system with a grid of raking and longitudinal poles, but is not clear enough for us to be certain of the details (Lennon 1992: 21).

Fig. 1. Charles Norton, 'Mr Birche's [*sic*] old hut': pencil sketch, La Trobe Collection, SLV, No. 966072, H88.21/73.

From the same year, however, we have an unequivocal illustration of a number of bark roofs at Perrott and Garde's 'Cathkin' station, sketched by Henry Godfrey (Godfrey, no date). Another good illustration is E. W. Jeffreys' sepia wash drawing of Campbell's 'Ghin Ghin' station on the Goulburn, with five bark roofed buildings (Cannon & Macfarlane 1988: facing page 300): but although the run was established in 1838 the illustration is later, and there is nothing to establish the dates of the structures. By contrast Birch's hut, sketched by Norton, may date from the later 1830s, in which case it could be the earliest authenticated Australian example.

SOLID BLUESTONE

The age of bluestone in the Western District is from about 1853 to 1900. It is hard to think of any substantial homestead in the region built of anything else—that is, there were lesser homesteads of timber, but almost none of brick, freestone or concrete. But however grand the houses, the designs are mostly conservative. The owners, so often Scots, were doubtless dour and practical, and in any case had little incentive to pursue the vagaries of fashion. The designers were commonly local builders, or builders who had turned themselves into architects, and were not likely to create anything unexpected. But even when Geelong or Melbourne architects were engaged, they seemed, for the most part, to succumb to the conservative tradition of the region. This makes the exceptions, which I will come to later, so much more interesting.

At 'Carranballac' there is a cottage built in two stages, one of which is inscribed with the date 1859. It has been claimed that the other undated portion is the earlier, but an examination of the junction makes it clear that it was added to the 1859 building. At 'Blackwood' there are two stone cottages, believed to be the first and second homesteads on the property, but no dates can be ascribed to them. At 'Ingleby' the 1860 house, referred to below, replaced a previous stone dwelling of unknown date.

Government and commercial buildings are better documented. The earliest unequivocally dated bluestone structure is the masonry portion of the road bridge over the Woady Yaloak at Cressy, dated 1854 by an inscription on the east abutment, though the superstructure was replaced in 1880 (tenders were called in the *Argus*, 27 March 1879, page 3, and the ironwork bears the plate of the contractors, Humble and Nicholson of Geelong, with the date 1880). A close competitor is the Old Timboon Inn (now 'Timboon House'), on the Old Geelong Road, Camperdown, which is believed to date from 1853–55 (Willingham 1980). If so, it is perhaps the earliest documented bluestone building in the region.

The standard Western District bluestone homesteads are simple, blocky and usually symmetrical, and there is nothing distinctive about their design. Any one of them could be built in brick in northern Victoria and it would not raise an eyebrow. The old bluestone homestead at 'Barwon Park' must date from after the pre-emptive right application of April 1855, for it's not mentioned in it, and it was doubtless the acquisition of freehold land which encouraged Austin to build it. It was a double-fronted cottage with a hipped roof, two dormer windows and a verandah (Willingham 1980: 16–21)—a common house form about this time, but shortly to disappear entirely. A more typical example is Point Cooke homestead, one of the Chirnside properties, which helpfully has its date, 1857, inscribed on the parapet. It also has a number of interesting features, notably the use of Arbroath stone paving, imported from Scotland, which is found at a number of sites in Victoria of the 1850s.

John Moffat's 'Chatsworth' of 1859–60 is in this same simple homestead tradition, notwithstanding the fact that it is a very grand house, famous for the fact that the Duke of Edinburgh stayed there in 1867. George Armytage's 'Ingleby' of 1860 is a very austere building, by the conservative Geelong architect Edward Prowse. It is interesting that his verandah roof is constructed with curved wrought iron rafters, but no battens to support the corrugated iron, essentially in the tradition of early fabric verandahs.

The date of 'Gnarpurt' near Lismore is unknown to me, but I believe it to be from after the cancellation of squatting licences, and on stylistic grounds the verandah at least must be of the 1870s. The house is on what had been the Little Corangamite (or Korangamite) run and must date from after the forfeiture of the licence in 1867 (Spreadborough & Anderson 1983: 116). The house, which falls into the same conservative tradition, has been considerably altered. However, it is interesting because it has a private chapel within it and a later detached bluestone chapel some distance away, as well as bluestone shearers' quarters and shearing shed of considerable quality, though probably later in date.

'Titanga,' Lismore, again dates from after the cancellation of the squatting licence of the Mt Elephant No. 2 run, when 'Gala' and 'Titanga' were formed (Billis & Kenyon 1974: 249). The house is by the Geelong architects Davidson and

Henderson, who were capable of quite innovative work, but here are conservative. Their drawings survive (held by Chris and Val Lang at the property—I understand that the papers relating to the property have been lodged with the State Library of Victoria), and are of special interest, because there are both timber and bluestone proposals for the house, almost identical apart from the materials. The bluestone design survives intact in the house of today, but with an added wing. So does the bluestone shearing shed, only a little later in date.

'Carranballac' is a Chirnside property, and the house is said to date from the mid-1860s, though the verandah, at least, is clearly later, and it also probably post-dates the forfeiture of the lease in 1868. [The lease was forfeited in 1866 but this was revoked, and the forfeiture finalised in 1868 (Spreadborough & Anderson 1983: 92).] An Ararat-based quasi-architect, Parlane Colquhoun, is known to have done work at the property in about 1871, and I suspect that he designed the house at this time. As an interesting aside, it contains a water closet pan branded both by the leading London maker, Jennings, and their agents, the Melbourne ironmongers James McEwan & Co. The Western District is the place to find such things, because there are large houses, usually occupied today by smaller families, so there is little pressure to renovate the surplus bathrooms.

We know that the Chirnsides brought Colquhoun to the You Yangs to design 'Mt Rothwell', of about 1872, because there is surviving correspondence, as well as Colquhoun's actual drawings. It is a crude design, contrasting oddly with the very elegant decoration done later on by John Clay Beeler.

Alexander Hamilton is another locally-based quasi-architect, originally a millwright, and was responsible for 'Eeyeuk' in about 1874, for his drawings survive. Plain though 'Eeyeuk' is, it is asymmetrical in an attempted picturesque way. It is also notable for having a very early septic tank, of 1908. (At ground level it shows two concrete slabs like beds placed end-to-end. Each bears a cast plate with an elaborate circular brand 'Non-Septic Oxidising Disposal Service'; 'Montgomerie Neilson/Edmunds Bros Sole Agents/ Box 1449 GPO'; 'Melbourne/Vic & Tas/Sydney'.) Wooriwyrite' at Kolora is by Hamilton nine years later and much the same in character—plain, though asymmetrical—and very conservative at a time when Melbourne architects were entering onto the Boom style.

But what is much more remarkable is that when a sophisticated Melbourne architect is engaged, he can be equally conservative. This is the case with 'Meningoort', designed by C. A. D'Ebro in 1886. D'Ebro was a leading Melbourne architect, responsible for fashionable houses such as 'Stonnington' in Malvern, and 'Meningoort' is indeed quite grand in scale and quality. But it nevertheless remains conservative and symmetrical, in the established Western District tradition.

There are exceptions to this conservative tradition, as we shall see, but first it is necessary to touch upon some of the subsidiary buildings.

FARM BUILDINGS

Farm buildings are even less likely to be datable than early houses and some of the most interesting are almost entirely mysterious. The earliest were not of bluestone, but of timber and bark, and D. E. Cooper's watercolors of 'Challicum' include one of his woolshed, in 1845 (Cooper 1845), whilst his journal records the actual cutting of the bark. The 'Challicum' woolshed does not survive, but a similar one, of the same age, still exists at 'Tottington' near St Arnaud; Former 28 stand woolshed, known to have been built by Lawrence Rostron in 1845. (Lawrence Rostron diary, Royal Historical Society of Victoria, as advised by Brian Smith of Tottington, 1999. The diary gives dimensions in accord with the present building, and details of cutting bark roof, floor slats etc.)

Vernacular bluestone structures, which may be of any date, include a drystone animal shelter, at 'Barunah Plains,' 16 km west of Inverleigh, and the sheepyards at Bessiebelle on the former 'Squattleseamere run', undated but known at least to be from before 1880 (Fraser 1981: 3/104). This is a remarkable complex of drystone pens and races, including a sheepwash. Two important examples of squared honeycomb basalt survive at Mt Hesse: the west part of the stables, of 1849, and the woolshed, of 1850—both of which are dated by inscriptions on them (Curtis 1969: 8.8).

More formal bluestone farm buildings include some grand shearing sheds, one of the most unusual being that at 'Kolor' (now on 'Teringa'), designed by Reed and Barnes in 1868. It has an unusual octagonal hub with rectangular arms extending from either side. There is perhaps some link, by way of the Twomey family, with a far more dramatic and completely octagonal shearing shed at 'Gostwyck' near Uralla, New South Wales (now on 'Deargee'), designed by Henry Dangar (Fraser 1981: 2/249).

There are also many notable stables. Those at 'Ingleby' are impressive and include a coach house, but seem to date from the 1882–83 additions by

A. T. Moran, not from the original work of Edward Prowse, for the remains of the earlier single-storey stables survived into recent years (Curtis 1969: 2.18). However, the stables at 'Chatsworth' may well be contemporary with Fox's house of about 1859–62. They are not remarkable in terms of style, but they comprise the greater part of a very long wing: another long wing at right angles to them contains the men's quarters, and between them these wings define the dimensions of an enormous square, like a parade ground. The 'Larra' stables, by Davidson and Henderson in 1873 (Billis & Kenyon 1974: 210) are very distinguished, on a sort of E plan, and even have a lightning conductor, unusual at this time (Fig. 2).

Subsidiary buildings for other than farming functional purposes are rarer, but they include the private chapel at 'Gnarpurt', already referred to, and a Turkish bath house at 'Dunmore', which carries a date plate of 1866.

Fig. 2. Stables, 'Larra', designed by Davidson and Henderson 1873: detail with lightning conductor. (Photo: author.)

HIGH STYLE ARCHITECTURE

The bluestone homesteads which are not of a conservative four-square form are a minority, but all the more interesting for that reason. 'Berrambool' at Willaura was designed by J. H. Fox (the architect of 'Chatsworth') for Thomas Maidment in about 1869, and has dramatic Scotch or Flemish gables. The addition of a verandah, somewhat later, has partially blunted its impact (an old photograph held on the property and seen in 1982, shows it verandahless).

The works of Davidson and Henderson are amongst the more eccentric. They were Geelong-based architects, very much under the influence of the French architect and historian, Viollet-le-Duc, and especially his *Dictionnaire* (Viollet-le-Duc 1854–68). But this influence shows more in their brick houses at Geelong, and in some churches, like St Andrew's Presbyterian Church, Skipton, of 1871, than it does in their country houses. The Skipton church has gargoyles and *congés* derived from illustrations in Viollet's *Dictionnaire* (Viollet-le-Duc 1854–68: VI, 23, sv *Gargouille*; III, 143, pl. 2, sv *Congé*; VII, 474, sv *Poteau*).

Davidson and Henderson's 'Titanga', as we have seen, is a typical conservative design. 'Barwon Park' at Winchelsea, designed by these architects for Thomas Austin, is a visibly clumsy building showing no explicit Viollet influence, but many idiosyncratic details, not the least of which are the factitious Austin family arms incorporated into the cast iron decoration. More interesting is Sladen's 'Ripple Vale', Birregurra, of 1871, but it seems that the architects may have been executing an imported design rather than one of their own. Their most significant house is 'Narrapumelap' at Wickliffe, of 1873–78. It has suffered much from decay and almost as much from the recent renovation, and it now lacks the top of the tower, which can be seen intact in an old view (Sutherland 1888: II, 9). Here there is at least a hint of Viollet in the battered tower base, which compares with a fortified gate illustrated in the *Dictionnaire*.

Whilst Davidson and Henderson made what use they could of Viollet-le-Duc, there is one other house in Victoria with a direct link to the Frenchman, which, though it is not in our primary region of concern, is nevertheless in bluestone territory. 'Woorookabanya', a property of the Bucknall family, has some internal Violletic details It is officially credited to W. R. Creber of Ballarat, an architect of no consequence. The reason for the Viollet details must be the fact that the owners were the relations of Benjamin Bucknall, Viollet's English translator (Viollet-le-Duc 1881).

The gem of Western District homesteads has to be 'Kolor' (Fig. 3), which, like its woolshed, was designed by Reed and Barnes for Daniel Twomey. It is interesting that J. H. Stanton, the clerk of works employed by them on the site, kept a diary which is now held by the State Library (Stanton 1868–69). But it has always seemed to me that this house was the work of Edward La Trobe Bateman (1816–97), who was a sort of artistic consultant to Reed's firm. He did landscaping for them, schemes of interior decoration, and it seems the overall styling of some buildings.

Bateman worked on the landscaping at 'Chatsworth House', not far from 'Kolor', and it was there that he was thrown out of a buggy, driven by John Moffat, on 13 September 1867. Bateman was severely hurt and remained partly paralysed, resulting in a series of lawsuits against Moffat, and Bateman's ultimate departure for Scotland in 1869. As the tenders for Kolor were called in April 1868, and Bateman's input would have to have preceded the accident, this may be his last work in Australia.

Bateman's involvement might remain an unsubstantiated hypothesis were it not for the fact that he prepared a scheme for a house and garden for Thomas Shaw, of 'Wooriwyrite'. This scheme was not carried out, and course the rather mundane house by Thomas Hamilton, referred to above, was constructed somewhat later. But the house shown by Bateman is unmistakably the sister of Kolor, and has the same very distinctive curved bay and verandah on the main front.

The last houses to mention in this group are two by the Melbourne architects Smith and Johnson: 'Green Hills' at Hawkesdale was built for John Ware in 1872–73 and designed by A. L. Smith, just prior to his partnership in 1873 with Johnson. Apart from the use of bluestone and of a nailhead moulded timber bressummer in place of a cast iron verandah frieze, it looks exactly like a Melbourne suburban villa. It is single storeyed and asymmetrical with a projecting canted bay containing segmentally-headed windows. George Russell's 'Golf Hill' at Shelford is a much more distinguished house, designed by Smith and Johnson in 1876 in a sort of French Renaissance style. By now, however, the dictates of fashion were proscribing the traditional bluestone homestead.

Fig. 3. 'Kolor', designed by Reed and Barnes (possibly Edward La Trobe Bateman) 1868–69. (Photo: author.)

BRICK *versus* BLUESTONE

The 1890s was a decade in which a struggle took place between brick and bluestone. Red brick, in the Queen Anne and cognate modes, had experienced a revival in the 1880s in metropolitan architecture, and the country was inevitably to be dragged along. So one sees examples of really interesting metropolitan architects trying to find some middle ground—to achieve something like a red brick effect without totally abandoning bluestone. There are three really important buildings in this category.

At 'Blackwood', near Penshurst, the young English architect Walter Butler, a fully accredited member of the Arts and Crafts movement in England, managed to create something very like the work of Edward Ould in England, but overwhelmingly red in tone. His original drawings survive. The bluestone walls are overcome by the scale of the half-timbered gables, terracotta roofs and brick chimneys.

'Purrumbete', at Camperdown, is in fact an older bluestone homestead extended in 1901 by the young architect Guyon Purchas. He was one of the very few Art Nouveau practitioners in Australia, though this is not immediately apparent on the exterior. The broad gables are reminiscent of those at 'Pastoria' near Kyneton, and suggest the influence of American architects like Cobb. The interior is famous for the Walter Withers' paintings in the hall, recording the epic of Manifold pioneering, settlement and success, and for the extraordinary Art Nouveau woodwork. The carving has traditionally been attributed to Robert Prenzel, but that is now in some doubt, and it certainly lacks the kitsch character of most of Prenzel's work.

The exterior is remarkable for some Chinese-looking metal lanterns and for bulbous terracotta verandah columns, with the latter forming an interesting link with future developments. In Purchas's office was the young pupil architect and later novelist, Martin Boyd. He was later, in 1927, to write about Australian domestic design in a London publication, the *British Australian and New Zealander*. He sketched what he described as 'A Bad type of Australian Villa' (M. Boyd 1927: 18)—the sort of house which was now, mercifully, being superseded. It has bulbous columns which are in fact by no means common and are clearly those of Purrumbete. Boyd is taking a disloyal swipe at his old employer.

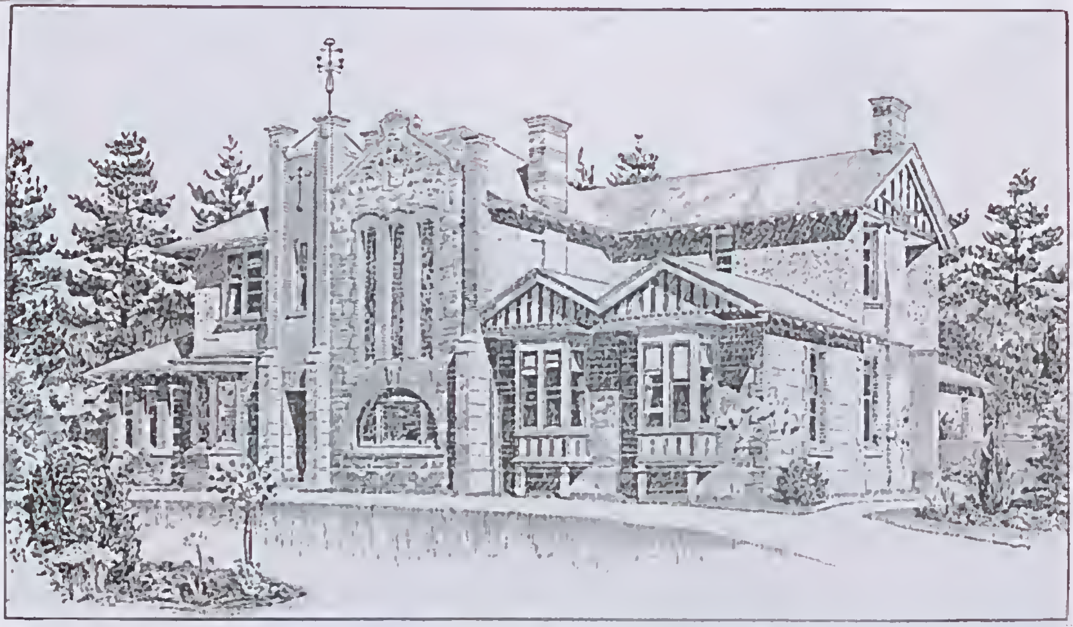

Fig. 4. 'Eurick', near Camperdown, designed by Sydney, Smith and Ogg (Robert Haddon) for C. S. Currie 1900–01: perspective by Haddon (from Haddon *c.* 1910: 150).

This shows something else as well. Boyd is using sketches, almost cartoons, for architectural propaganda purposes. He has laid out exactly the path which was to be followed by his nephew Robin Boyd, especially in his book *Australia's Home* (R. Boyd 1952).

The culmination of the battle between brick and terracotta was C. S. Currie's house 'Ettrick' of 1900–01 (Fig. 4), which makes a virtue of the conflict by pretending to be what Purrumbete actually is—a bluestone house, altered and extended in the age of brick and terracotta (Haddon 1908: 150; Smith 1903–05: II, 294). The house is nominally by the firm of Sydney, Smith and Ogg, who are not very distinguished in their own right. However, they regularly used the services of Robert Haddon, whose Modern Drawing Office would undertake the styling of buildings for less advanced or competent architects. Indeed, the drawings in this case were executed by Haddon, who initialled them, and there is little doubt that this should be seen as a work by Haddon.

This is obviously an essay in the picturesque, but it is more than that. It tries to give the impression of a building extended and altered over a period of time—and it succeeds. One would think, to look at it, that there was a bluestone house of the 1850s somewhere at the core, extensions in the 1870s and 1890s, and additions to the upper floor, perhaps in the 1920s. The principle is one which began with Horace Walpole's Strawberry Hill, and was even stronger in James Wyatt's Lee Priory, which, according to one description, conveyed 'an idea of a small convent attempted to be demolished, but partly modernised and adapted to the habitation of a gentleman's family'. But Ettrick may well be the last serious essay of the sort prior to the age of post-modernism.

'Newminster Park', also of 1901, is as good an example as any of the final defeat of bluestone. For the first time a major house in the bluestone territory was built entirely in brick, and henceforward this was to be the rule. 'Newminster Park' has not survived, but nor has bluestone returned.

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MEDITATIONS ON THE MOUNT

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Victorian artist Noela Stratford chose Mt Elephant as a site for a project in which she examined the metaphorical properties of the mountain symbol through painting, drawing and as a personal journey. She researched the psychological and physical associations of the mountain symbol, its significance in art history, the mythology of many cultures and relevant issues.

Her project examined the distinctive shape of the old volcano, the circular form of its crater, the texture and warmth of the earth, the variations of its moods, and the meaning that is implied by its presence. The focus was on the role of the symbol and the form of its interpretation in the expression of ideas and images presented in the final series of paintings and drawings.

In this paper she describes how her preliminary research contributes to one particular painting, her methods in combining the material elements of painting with the ideas that inspired the work, and her utilisation of metaphor and symbol to communicate her experience of the site.

THROUGHOUT the world, people of traditional religious cultures, both Eastern and Western, have looked up to mountains as symbols of hope, places of transformation and transition to higher levels of spiritual experience. Pilgrimages to them can become metaphors for our own journey to understanding and the accomplishment of our spiritual goals. The human desire to break away from everyday concerns and events, and move to a place of stillness and peace, transgresses the limitations of time and cultural difference.

Symbol, metaphor and translation

My research into this topic concerned the significance of the mountain as a symbol that triggers ideas and impressions that are not necessarily related to the physical limitations of its appearance. Symbolic connotations can add new value to what we see, linking many diverse factors by a system of correspondences and associations. This interest was to manifest a need to find metaphorical equivalents for the layers of experience and perception, ideas and beliefs that we superimpose on whatever we see before us.

An understanding of the use of metaphor was important, and a vital part of my study has been to clarify my understanding of how this works; the way that two disparate factors—objects or events—can be put together to produce a new reference, producing an insight or imaginative leap that would not have been possible without this juxtaposition.

This means that our perception of the everyday world of objective things is set aside or suspended allowing for the possibility of new insights and meanings; the way we experience a landscape depends on both what we see before us and our own inner interpretation of it. When we put the two sign systems together (eg. the mountain itself and what it represents in our minds), new insights are provided that transcend the literal view and assist in formulating a more profound experience of place.

In the 19th Century, one of the great masters of Japanese art, Katsushika Hokusai, focussed his attention on the perfect cone of Mt Fuji. Hokusai believed the peak to be sacred, a symbol of immortality and stability; the ultimate embodiment of the divine light of spiritual wisdom (Shipposanka 1988). Between 1831 and 1835 he produced a series of prints entitled 'One Hundred Views of Mt Fuji', demonstrating his familiarity with contemporary religious beliefs and practices.

The Post-Impressionist artist, Paul Cezanne, also worked on the theme of the mountain. Like Hokusai, he concentrated on one location: Mont Sainte-Victoire near his home in Aix-en-Provence in France. Cezanne approached it from all angles of view, sketching and painting it repeatedly. He regarded the repeated sessions of working with the one motif as a form of meditation (Clark 1976).

In 1945, American artist, Georgia O'Keeffe, settled in the mountains of New Mexico. These hills represented for her a stability, simplicity and honesty that was inherent in natural forms, and struck a resonance with her own inner resources. O'Keeffe's method of painting the hills near her home is reminiscent of the meditative approach of Cezanne and Hokusai. By repeatedly painting those hills she formed a ritual that provided a means of making them her own (Lisle 1980).

The project

I liked the idea of focussing on one geographic location and working with it exclusively. My plan was to produce a series of 100 small images forming a documentation project of one site—the mountain/hill/volcano: Mt Elephant. Mt Elephant is a monumental marker beside the Hamilton Highway at Derrinallum in Victoria. From many angles it is thought to resemble a resting elephant and as such is a recognisable form. As with Mt Fuji, it becomes a symbol of place—a dominant land form in this region, visible throughout most of the volcanic plain in this part of Victoria. My aim was to examine the potential of the symbol in an expanded sense. I wanted to develop my understanding of the way such a symbol works, both on the level of its physical presence and the resulting psychological effects, on the viewer.

On a physical level, it could be seen in terms of its location, silhouetted shapes, the texture of its surfaces, contrasting angles of view, color, light and form. On a psychological level; the mass of the land form as it rises up before us, the silence of its dormancy, the metaphorical inferences of brooding, a mediative stillness: a presence that mediates between earthly and heavenly matters. Consideration could also be given to the sense of enclosure in the crater, intimations of safety on reaching the inner sanctum and a hint of infinite unknown depths, suspected but not known.

My painting 'Reconciliation: One Hundred Views of Mt Elephant' was originally planned to be an open-ended project. Because of its size it needed the freedom to develop as I worked on it rather than having a preconceived plan. Initially, I worked from the periphery, moving around the site, drawing and photographing the shape as it changed. My aim was to build up a bank of information to use as I moved through the series. This recording of shapes was important: this is the aspect of the mount that distinguishes it from other volcanic formations in the area.

As I moved in closer, climbing the hill, more details were apparent: textures and tones that were not visible from a distance. Reference to the scoria mining that has taken place on the western face was part of the recorded material. My aim was to present an image that is a literal reference to the site itself, overlaid with words and maps related to my own experience of being there. My journal notes record this entry:

> *Mt Elephant acts as a focus: a navel in the belly of the smooth flat plain. It consists of a circle formed by the sides of a dormant volcanic cone with a peak at the south-east end; the centre of the crater has two mounds, remnants of lava arrested as a seal.* (Stratford 1993)

I began this project by collecting fragments: reading about mountain forms, the mythology, geology and history that is associated with them; drawing angles and views; examining changes in the shape, moving in closer; feeling the stone, the heat and pieces of scoria. This mountain or hill form is part of the earth, part of my surroundings. From a distance it has become a medallion-like form marking the journey past. On many journeys, I see it in different moods and experience a range of feelings and thoughts that are not necessarily connected to the physical form of the hill.

When I first reached the central crater, I became more aware of the even, circular nature of the form that I had been surprised to see in an aerial photograph of Mt Elephant. To me it represents a mandala; a circular form that is used in meditation (Fig. 1). The image of this circular form seemed to unite the fragments that represented the 100 views and to bring them together, unifying or reconciling the fragmentation of the component parts.

Moving from a distant view to a direct confrontation with the slopes of the crater, I aimed for a synthesis of the perceptions gained in the process. I began by gridding up a large canvas

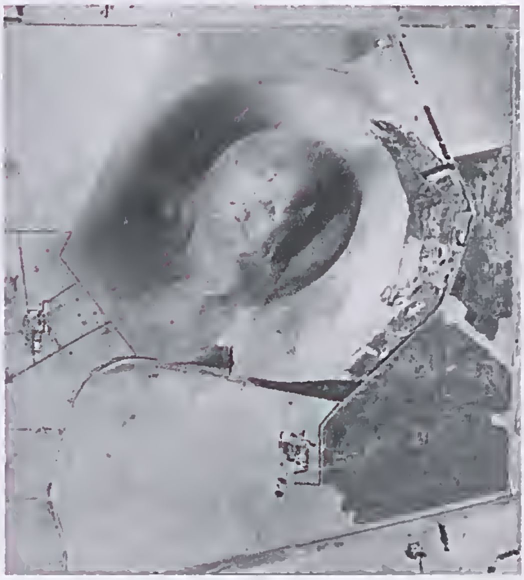

Fig. 1. Aerial view of Mt Elephant, Derrinallum, Victoria. (Photo: Department of Survey and Mapping Victoria, 1992.)

into 100 parts, applying broad washes of acrylic paint; concerning myself with a general compositional balance, then moving back to the more detailed aspects of the image. This process of moving from the general to the particular and back again continued throughout the execution of the work. The repetition and division into component parts presents images simultaneously to each other and against each other. Finally, the circular form of the aerial view is superimposed over this series of images, uniting the forms and effecting a reconciliation of the collected fragments (Fig. 2). My intention was to present the results of many journeys, many experiences, drawn into one converging point that focuses a multiplicity of forms into one single image.

When I set out to examine the significance of the mountain symbol, I embarked on a journey that took me through several stages in the development of my understanding of the processes involved in the quest. I began by focusing the disparate elements then moved on up the slopes, eventually reaching the peak and the completion of my project. The achievement of a clearer focus and perspective after a long engagement with my topic equates this result.

In a culture that has largely turned its back on the natural environment, it is imperative that we extend our understanding of the role that landscape symbols play in developing our perceptions of the world. I believe that our task for the new century is to re-examine these vital relationships and to consider the way we seek and find meaning within a complex world.

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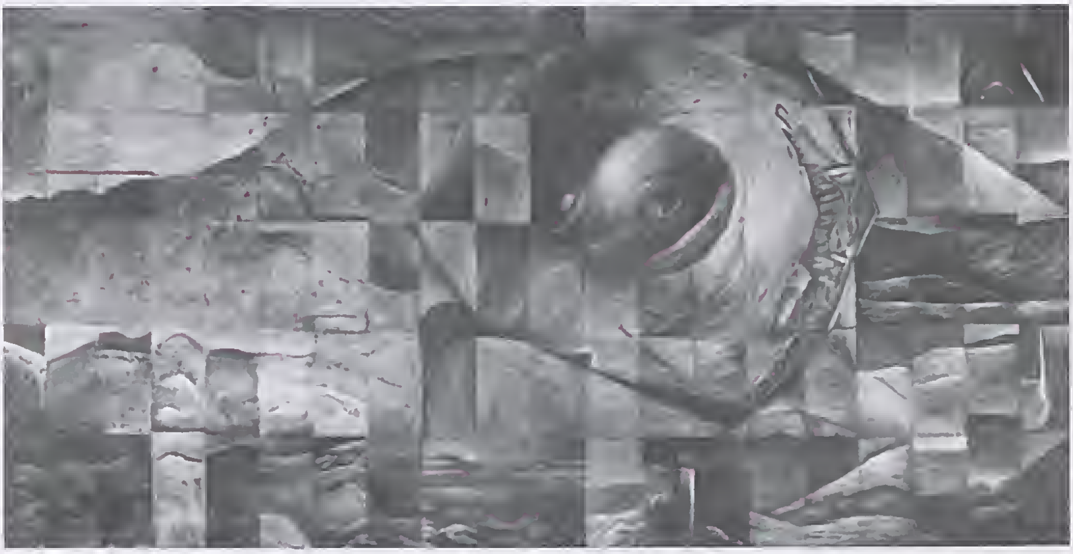

Fig. 2. 'Reconciliation: One Hundred Views of Mt Elephant', Noela Stratford (1993). Acrylic and oil on canvas, 1220 × 2410 mm.

BIRDS OF THE BASALT PLAINS

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The abundant wetlands and relative lack of trees on the basalt plains have determined its birdlife. Some species have disappeared, such as the Bustard, but many others have adapted to European settlement and actually increased in number. Previously exploitative attitudes have changed and landholders have become generally protective of birdlife. We must continue to maintain wetlands, native pasture and existing tree cover to maximise the outlook for native species.

THIS brief overview of the birdlife of the basalt plains focuses on species found in an area extending for a distance of 30 km from Lismore, Victoria, where the author is based, and including the scoria cone of Mt Elephant, 11 km west of Lismore. It owes a debt to an earlier similar work (Middleton 1984) as well as the observations of a number of birdwatchers in the local area. It is by no means comprehensive or authoritative but is intended to stimulate debate by pointing out some features which might be of interest.

The topography of the basalt plains at the time of European settlement has been well established; an open expanse of treeless or lightly wooded plains, with a scattering of trees and shrubs amongst a thick herbage of kangaroo grass and native wildflowers in the more elevated areas, and, in the depressions, extensive tussock-grass swamps. Extinct volcanoes and large freshwater and salt lakes dotted the landscape, whilst denser vegetation marked the creeks and rivers. The absence of woodland and the ample availability of water have shaped, and continue to shape, the dominant bird species to be found in the district.

The close relationship between native Aboriginal inhabitants and the land was documented by a number of early observers, although many details of this affinity have sadly been lost. Amongst a wealth of natural resources exploited by the Aborigines were birds such as emus, bustards and quail, hunted in the grasslands, and wildfowl and swans, in the swamps (Dawson 1881).

The lush pastures of the Western Plains were rapidly occupied by European pastoralists during the late 1830s with immediate effects on the environment. Some insight into the birdlife in this early period comes from a description by a recently-emigrated shepherd, at 'Larra' station, lying alongside Mt Elephant (Marshall 1852):

> *It is a splendid country, grass, sheep and cattle very fat ... there is a mount on the station shaped like an elephant ... the plains around are bedded with stones from it ... there are three lakes on the border of the station with plenty of wildfowl on them, wild duck, wild turkey, wild swans, pelicans, native companions [brolgas] and a variety of other kinds*

Despite the draining of numerous swamps to increase pasturage, the relative abundance of water in the district has continued to support an abundance of waterbird life, especially in good seasons. But a number of species which Marshall would have seen have since disappeared from the basalt plains entirely. Amongst these are the Magpie Goose, now the symbol of Kakadu, and the majestic 'wild turkey' or Australian Bustard, doomed by game shooting and disturbance of their habitat.

Most records of birdlife in the 19th Century come from specimens 'collected' by naturalists and lists of game shot by various 'sportsmen'. One of the latter was a pastoralist, Joseph Mack, who lived at Berry Bank station between Lismore and Cressy from 1864. His station diary describes the birds he shot, especially the Bustards, of which he was particularly proud. Early entries note the abundance of the bird, including a 10 kg Bustard shot in June 1869. Mack then notices the bird becoming shyer: in December 1874 he saw over 80 'turkeys', 'but they were very wild'. And finally, on Christmas Eve, 1886: 'shot "Xmas dinner" but it flew away—first time for over 20 years that I have not got a turkey for Xmas' (Mack 1864–86). The Bustard was in fatal decline. The last birds seen near Mt Elephant were a flock which survived at West Cloven Hills, probably into the 1950s, and still remembered by local residents. Soon even the memory of the bird will be gone.

Gone much earlier was the Emu, rapidly succumbing to the competition from sheep and cattle. Other less obvious grassland birds probably disappeared from the plains without even being noticed. One of these was the mysterious Bush Stone-curlew whose eerie call has not been heard

in the plains for a number of decades. It survived until comparatively recently in the station drive of one homestead, but then vanished when someone 'tidied up' its habitat. The emblem of the plains, the Plains Wanderer, a curious nocturnal resident of native pasture, was probably once common in suitable habitat. It is now rare in Victoria and has not been seen locally since 1964, although there was a record of three birds in grassland near Cressy in the 1990s.

Despite these losses there is still an abundance of bird life which can be readily observed in the plains: some 220 species have been recorded within 30 km of Lismore (see Table 1). These are characterised by a wealth of wetland birds, many birds of prey and types of parrot, and various migratory birds, some from far afield. Some birds, otherwise widespread in a variety of habitats, such as the Superb Fairy-wren and Eastern Yellow Robin, are rare or absent from the plains.

Immediately identifiable in most wetlands are numerous duck species which can mass in many thousands in favourable conditions. Grey Teal and Pacific Black Ducks are particularly common. The bizarre male Musk Duck has a large flap of skin under its bill which it uses in its mating display. Another familiar wetland bird is the Hoary-headed Grebe, seen bobbing like a small bath toy on the water. Herons, egrets and allied species are common. The White-necked Heron has been widely observed this year along with a number of sightings of the uncommon Royal Spoonbill.

The Cape Barren Goose has a restricted distribution in Tasmania and south-eastern Australia, where its stronghold is around Lake Corangamite. The wetlands attract other birds, such as the dainty Whiskered Tern, believed to be the 'sea-swallow', which may have provided the basis of the native name for Mt Elephant (Derrinallum) (Currie 1866).

The muddy margins of drying wetlands attract a variety of non-breeding migratory waders from distant parts of the world. The most common of these is the Red-necked Stint, a tiny bird which breeds in Arctic Siberia and northern Alaska and flies huge distances to the Southern Hemisphere for spring and summer. Amongst the native waders, perhaps the most noteworthy is the Pied Stilt, which often masses in gleaming white flocks of many thousands in lakes with a level of salinity intolerable to many other birds (Fig. 1).

The skies are the domain of a range of raptor species which seem to have adapted well to European settlement: the open plains suiting their method of hunting and an abundance of introduced mice and rabbits replacing their native prey. The largest of these birds, the Wedge-tailed Eagle, can regularly be seen lazily soaring on thermal air currents over Mt Elephant, often accompanied by Whistling Kites. The strikingly beautiful pure white form of the Grey Goshawk is an occasional visitor in winter, placing fear into the hearts of smaller birds. Another hunter, but by night, the Tawny Frogmouth, waits out the day perched motionless on a tree branch where it blends in with its surroundings.

Some bush birds have benefited from the nesting hollows provided by plantations and the ample seed available from introduced weeds and grasses. Particularly evident along roadsides are a number of resident parrot species including Red-rumped Parrots and Eastern Rosellas. The Long-billed Corella, once considered threatened because of its limited distribution, now forms large raucous flocks around food sources. Garden shrubs and eucalypt blossom attract nectar feeders such as Musk Lorikeets and some species of honeyeaters.

The beautiful Flame and Scarlet Robins provide flashes of color in winter, migrating from the highlands and Tasmania, and glimpsed on fence posts or perched on the heads of thistles. Sadly, their numbers have declined noticeably in recent years with the development of modern farming techniques. Many other birds visit the plains for part of the year. In recent months there has been an invasion of Black-tailed Native Hens from inland; Brolgas have been reported nesting in a number of places, and White-winged Trillers and Rufous Songlarks have recently arrived from northern Australia.

We have much to be thankful for that we still have such birds to see; in general, birds of the grasslands have survived comparatively well compared to native flora and mammals, because of their relative adaptability to changes in habitat and food sources. There is also some cause for optimism in the more enlightened attitude of many landholders, who, far from the organised slaughter of wildlife which characterised past eras, now prohibit shooting and take great pride in their birdlife.

But there is still much to be done. Wetlands must be protected and extended; remnant native vegetation needs to be maintained; roadside plantations kept for important nesting hollows; and new trees planted wherever possible. We do not want to see again a dry and barren lake bed where once thousands of waterfowl filled the air with their cries, but instead the joyful sight of a restored swamp with all its abundant life and hope.

Who knows, perhaps one day some of those vanished species may eventually return to the plains where they belong. The future is in our hands.

Australasian Bittern
Australasian Grebe
Australasian Shoveller
Australian Bustard
Australian Hobby
Australian Magpie
Australian Owlet-nightjar (1 record)
Australian Pelican
Australian Pratincole (2 records)
Australian Raven
Australian Shelduck
Australian Spotted Crake
Australian White Ibis
Australian Wood Duck
Baillon's Crake
Banded Land-rail
Banded Lapwing
Banded Stilt
Barn Owl
Bar-tailed Godwit (2 records)
Bassian Thrush (2 records)
Black Falcon
Black Honeyeater (1 record)
Black Kite (1 record)
Black Swan
Black-chinned Honeyeater (4 records)
Black-faced Cuckoo-shrike
Black-faced Woodswallow (1 record)
Black-fronted Dotterel
Black-shouldered Kite
Black-tailed Native Hen
Black-winged Stilt
Blue-billed Duck
Blue-winged Parrot
Brolga
Brown Falcon
Brown Goshawk
Brown Songlark
Brown Thornhill (2 records)
Brown-headed Honeyeater (3 records)
Brown Quail (1 record)
Brush Bronzewing (1 record)
Budgerigar (3 records)
Bush Stone-curlew
Cape Barren Geese
Caspian Tern
Cattle Egret
Chestnut Teal
Clamorous Reed Warbler
Cockatiel (3 records)
Collared Sparrowhawk
Common Blackbird*
Common Bronzewing
Common Greenshank
Common Sandpiper (1 record)
Common Skylark*
Common Starling*
Crested Pigeon
Crested Shrike-tit
Crimson Rosella
Curlew Sandpiper
Darter
Dollarbird (1 record)
Double-banded Dotterel
Dusky Moorhen
Dusky Woodswallow
Eastern Rosella
Eastern Spinebill
Eastern Yellow Robin (1 record)
Emu
Eurasian Coot
Eurasian Golden Plover (1 record)
European Goldfinch*
European Greenfinch*
Fairy Martin
Fairy Prion (2 records)
Fan-tailed Cuckoo
Feral Pigeon*
Flame Robin
Forest Raven
Fork-tailed Swift
Freckled Duck
Fuscous Honeyeater (1 record)
Galah
Gang-gang Cockatoo (3 records)
Glossy Ibis
Golden Whistler
Golden-headed Cisticola
Great Cormorant
Great Crested Grebe
Great Egret
Grey Butcherbird
Grey Currawong (2 records)
Grey Fantail
Grey Goshawk
Grey Shrike-thrush
Grey Teal
Gull-billed Tern
Hardhead
Hoary-headed Grebe
Horsefield's Bronze-cuckoo
House Sparrow*
Intermediate Egret (1 record)
King Quail (1 record)
Latham's Snipe
Laughing Kookaburra
Lesser Sand Plover (1 record)
Letter-winged Kite
Lewin's Rail (2 records)
Little Black Cormorant
Little Button-quail (1 record)
Little Corella
Little Curlew (1 record)
Little Eagle
Little Grassbird
Little Lorikeet
Little Pied Cormorant
Little Raven
Long-billed Corella
Long-toed Stint
Magpie Geese
Magpie-lark
Mallard*
Marsh Sandpiper
Masked Lapwing
Masked Woodswallow (1 record)
Musk Duck
Musk Lorikeet
Nankeen Kestrel
Nankeen Night Heron
New Holland Honeyeater
Noisy Miner
Olive-backed Oriole (3 records)
Olive Whistler (1 record)
Pacific Black Duck
Pacific Golden Plover (1 record)
Painted Button-quail (1 record)
Painted Snipe (1 record)
Pallid Cuckoo
Peaceful Dove (2 records)
Pectoral Sandpiper (3 records)
Peregrine Falcon
Pied Cormorant (2 records)
Pink Robin
Pink-eared Duck
Plains Wanderer
Plumed Whistle-duck
Purple Swamp Hen
Purple-crowned Lorikeet
Rainbow Bee-eater
Rainbow Lorikeet
Red Wattlebird
Red-backed Kingfisher (1 record)
Red-browed Finch (3 records)
Red-capped Dotterel
Red-chested Button-quail (1 record)
Red-kneed Dotterel
Red-necked Avocet
Red-necked Stint
Red-rumped Parrot
Restless Flycatcher
Richard's Pipit
Rose Robin
Royal Spoonbill
Ruff (1 record)
Rufous Fantail
Rufous Songlark
Rufous Whistler
Sacred Kingfisher
Satin Flycatcher
Scarlet Robin
Sharp-tailed Sandpiper
Shining Bronze-cuckoo
Short-tailed Shearwater (1 record)
Silver Gull
Silvereye
Singing Bushlark
Singing Honeyeater (1 record)
Southern Boobook
Spotless Crake (1 record)
Spotted Harrier
Spotted Pardalote
Spotted Turtle-dove* (1 record)
Straw-necked Ibis
Striated Field-wren
Striated Pardalote
Stubble Quail
Sulphur-crested Cockatoo
Superb Fairy-wren (2 records)
Swamp Harrier
Swift Parrot (4 records)
Tawny Frogmouth
Tawny-crowned Honeyeater (2 records)
Tree Martin
Varied Sittella (1 record)
Wedge-tailed Eagle
Welcome Swallow
Western Gerygone (1 record)
Whiskered Tern
Whistling Kite
White-breasted Sea-eagle (3 records)
White-browed Woodswallow
White-eared Honeyeater (1 record)
White-faced Heron
White-fronted Chat
White-fronted Honeyeater (1 record)
White-naped Honeyeater (2 records)
White-necked Heron
White-plumed Honeyeater
White-throated Needletail
White-throated Treecreeper
White-winged Black Tern (2 records)
White-winged Chough
White-winged Triller
Willy Wagtail
Wood Sandpiper (1 record)
Yellow-billed Spoonbill
Yellow-faced Honeyeater
Yellow-rumped Thornbill
Yellow-tailed Black Cockatoo
Yellow-tufted Honeyeater (1 record)

Table 1. Birds recorded within 30 km of Lismore on the basalt plains. * indicates introduced birds; birds with five or fewer sightings are noted; resident birds now extinct are *italicised*; thanks to Mr R. M. Hughes for many of the records.

Fig. 1. Banded Stilt on Lake Milangil, 26 January 1999.

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A BRIEF HISTORY OF THE DERRINALLUM BUTTER FACTORY

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THE Western District has always played a leading role in the development of the Victorian dairy industry. The first cheese factory was established by Gilman Goodrich Pierce at Allansford, in 1869, using technology imported from America. The first cooperative butter factory in Victoria was established at Cobden by local farmers and Western District butter has always set the standards for top quality butter.

Prior to 1888, the manufacture of butter and cheese in Victoria was mainly a farmyard affair. Cheese was made by a few specialised dairy farmers who had the skill and equipment. As well, several cheese factories had been established across Victoria. Butter making, however, was not a specialised industry and was a household chore on most farms across the colony, usually carried out by the women of the family.

Techniques of butter making were very simple. Milk was allowed to settle in large shallow tin trays until the cream had risen to the surface. The cream was then skimmed off using a perforated tin hand skimmer and after a period of ripening, the cream was churned to butter in a hand-operated dash or box churn. Butter that was surplus to a household needs was usually salted down (known as potted butter) and bartered or sold at a local general store or sold to butter collectors who toured the countryside

In 1888, the Victorian government introduced a range of measures to encourage modern dairy practices including appointing a government dairy expert, establishing a travelling dairy and paying bonuses to establish cooperative butter factories.

These measures led to a wave of butter factories and creameries across the Western District, with substantial cooperative factories in the areas more favourable to dairying at Colac, Camperdown, Cobden, Glenormiston, Grassmere and Koroit, and smaller cooperative and proprietary factories in the more marginal areas. By 1914, there were 17 cooperative factories and 10 proprietary factories across the Western District (see Tables 1, 2).

Name of factory	Creameries attached	Year's output in tons	Class of supply	Name of manager
Apollo Bay		125	Cream	F. G. Martin
Byaduk		58	Cream	L. D. Crockett
Camperdown	Bostock's Stonyford	1191	Milk and cream	J. Proud
Carlisle River		62	Milk and cream	P. Clinger
Cobden	Bostock's Creek, Dixie, South Purrumbete	450	Milk and cream	D. Cameron
Colac—Corrorooke (Colac Dairying Co.)	Beec, Eurack, Alvie, Nalangil, Swan Marsh, Wool Wool, Warrion	2089	Milk and cream	W. L. Watson
Coleraine		208	Milk and cream	W. Kerr
Condah		115	Milk and cream	T. Moore
Derrinallum			Milk and cream	F. J. Rogers
Garvoc		221	Milk and cream	J. Martin
Glenormiston		767	Milk and cream	H. McKenzie
Grassmere	Wangoom, Purnim, Framlingham	422	Milk and cream	A. H. Davies
Koroit		508	Milk	J. Lucas
Macarthur		118	Cream	W. J. Malcolm
Mortlake				T. McCann
Penshurst		182	Milk and cream	T. Powell
Portland		66	Cream	T. W. Lightbody
Terang		151	Milk and cream	G. Fagan

Table 1. Cooperative factories (1914). *Source:* Department of Agriculture, Victoria, List of butter and cheese factories in the State of Victoria, 1914.

Prior to the establishment of the butter factory at Derrinallum, there were already several dairy farmers producing cream, which was carted to a receiving station situated near the railway station. From there the cream cans were picked up by the mail contractor and carted to the Camperdown Butter Factory. Early dairy farmers were Fred Taylor, Tom Heard, W. Stone, H. Stone, Alf Poole, Julia Campbell, Charlie Stewart and Skenes. Later farmers were Thomas Alexander, John Brown, Adam Fenton, David Fenton, Charles Biggin, Robert Horwood (banker), Arthur Woolley, Charles Hill, Gordon French, Jack Pollock, William Thornton, Robert Fryers, Garfield Hill and J. McCunnie.

On the 22 January 1914, a prospectus for the Derrinallum Cheese and Butter Factory Co. Ltd was issued, with five local graziers consenting to be directors (with J. Stewart as secretary):

- Currie, Henry Alan, 'Mt Elephant', Derrinallum, grazier
- Currie, John Lang, 'Larra', Camperdown, grazier
- Oman, David Swan, 'Highton', Lismore, grazier/MLA
- Oman, William, 'Bonnie Doon', Derrinallum, grazier
- Maconochie, James Alexander, 'Poligolet', Derrinallum, grazier

Brothers Alan and John Currie and William Oman had developed five or six farms on each of their stations, with the farms being leased out to farmers who were prepared to engage in dairying. On Larra the six dairies where leased to Frenchs, Fryers, Pollocks, Thortons, Garhills and Bushes.

The objective of the company was to establish a butter factory adjacent to the railway line and serve the area along the railway from Gheringhap to Maroona. It stated that the adjacent area was suitable for dairying and owners of land in the neighbourhood had shown interest in making 3000 to 4000 acres available for dairy farms. The prospectus noted that numerous applications were being received from prospective tenants. The factory was to be modelled on the Camperdown factory and also aimed to supply electricity.

The company was based on 12 000, £1 shares, with two types of shares—producer shares and non-producer shares. It was stipulated that holders of producer shares who farmed within a 6-mile radius of the factory, shall supply the whole of their milk and cream to the company or render their shares liable to forfeiture. By 1 June 1914, 3369 shares had been allocated and the company was duly registered. Table 3 shows the shareholders list.

An $11^{1}/_{2}$-acre site near the railway station was selected, and plans submitted for the factory by Mr Crawley, the architect, were accepted. By April, Mr James Hogg had begun erection of the factory at a tendered price of £2428. Equipment installed included a 10 hp boiler, 8 hp Tange suction gas plant and an engine, which operated the refrigeration plant, two butter churns, a butter worker, and skim milk, buttermilk and cream pumps. Mr Fred Rogers was appointed the first manager of the factory on a salary of £300 p.a.

On 21 September 1914, the first churning of cream took place. The butter made was of excellent quality and was consigned in 56-pound blocks to Western District Factories Cooperative Produce Co. of Melbourne, in which the factory held five shares. The factory paid $11^{1}/_{2}$ pence per pound.

Meanwhile, more dairy farms had been established on the Mt Elephant, Larra and Poligolet stations to maintain the supply of cream to the factory.

Name of factory	Year's output in tons	Class of supply	Name of proprietor
Pomborneit	4 tons condensed concentrated dried milk	Milk and cream	Bacchus Marsh Milk Co.
Merino		Milk and cream	J. E. Handbury & Son
Beech Forest		Cream	Hansen Farrell Co.
Hamilton	107	Milk and cream	Holdenson & Nielson
Studbrook	168	Cream	Holdenson & Nielson
Laang (Arundel via Panmure)	170	Milk	Millard & Johnstone
Port Fairy		Cream	Dalton Bros
Premier (Warrnambool)		Cream	W. Warren
Sisters (Terang)	150	Milk and cream	Wood & Co.
Casterton	175	Cream	Wood & Co.

Table 2. Proprietary and private butter companies (1914). *Source:* Department of Agriculture, Victoria, List of butter and cheese factories in the State of Victoria, 1914.

However, the young factory did not have it easy. During 1914, the country experienced one of the worst droughts ever recorded, as well as the outbreak of war, and the factory had to cease its production for a time. Most farmers lost nearly all their cows and those who did save their cows found they were not as productive as they were before the drought. In the first annual report to 31 August 1915 the directors reported a loss of £61-13-10 and commented,

Your Directors regret that, due to the unprecedented drought through which the district has passed, the estimated output of the Factory has been considerably less than anticipated and consequently the price paid for butter-fat was disappointing to producers.

(Derrinallum Cheese and Butter Factory, Directors report, 1915)

The first balance sheet showed that the factory

Shareholder	Home location	Occupation	Number of shares
Bennett, Charles	Darlington	Mason	50
O'Donall Edward	Lismore	Farmer	10
Currie,Henry Alan*	Mt Elephant, Derrinallum	Grazier	500
Rowlins, Richard	Derrinallum	Farmer	10
Adams, Hubert A.	Lismore	Printer	25
Hexton, William	Larra, Camperdown	Labourer	50
Stewart, James	Larra, Camperdown	Manager	50
Edgar, William	Gala, Lismore	Overseer	10
Jackson, Stanley	Oomoo, Derrinallum	Grazier	50
Jackson, Gordon	Oomoo, Derrinallum	Grazier	50
Strachan, Murray & Shannon	Geelong	Agents	40
Currie, John Lang*	Larra, Camperdown	Grazier	500
Oman, David Swan*	Highton, Lismore	Grazier/MLA	25
Mclean, Francis	Derrinallum	Farmer	10
Horwood, Robert S.	Derrinallum	Bank manager	5
Oman, William*	Derrinallum	Grazier	100
Wells, Frederick Hubert	Derrinallum	Farmer	5
Lang, Stewart	Titanga, Lismore	Farmer	250
Taylor, Francis	Derrinallum	Farmer	5
McLean, Mary	Derrinallum	Grazier	25
Maconochie, James Alexander* & Maconochie, Thomas Andrew	Poligolet, Derrinallum	Graziers	300
Heard, Thomas James	Derrinallum	Farmer	5
McCall, Allan	Dundonnell	Farmer	4
Baker, Edmund	Lismore	Farmer	10
Currie, Charles Sibbald	Ettrick, Camperdown	Grazier	500
Stone, Henry William	Derrinallum	Farmer	5
Odlum, Charles	Derrinallum	Plumber	10
Taylor, Alfred Ebenezer	Darlington	Storekeeper	10
Oman, James & Oman, Gardner	Lismore	Farmers	40
Stewart, William Drennan	Ettrich, Camperdown	Farmer	10
Robertson, John	Lake View, Dundonnell	Farmer	20
Currie, Edwin	Gala, Lismore	Grazier	500
Barrie, Margeret	Ettrick, Camperdown	House duties	10
Barrie, Jean	Ettrick, Camperdown	House duties	10
Cuming, Claude Percival Tyans	Stonehenge, Derrinallum	Grazier	100
Stanmore Moodie & Co.	Camperdown	Agents	20
Douglas, George	Derrinallum	Boardinghouse keeper	10
McQualter, William	Derrinallum	Sadler	5
Westcott, Clarence William	Armstrong St, Ballarat	Agent	5
Jeffree, Samual Philip	Service St, Ballarat	Agent	5
Dalgety & Co. Ltd	Melbourne	Agent	20
		Total	3369

Table 3. Shareholders in the Derrinallum Cheese and Butter Factory Co. Ltd (1 June 1914). *Director. *Source:* Derrinallum Cheese and Butter Factory, List of shareholders, 1914.

and land cost £3837-2-3 and the plant cost £2161-7-8. Cream purchases cost £4139-1-3 and butter sales realised £5497-15-0, which would indicate that the factory manufactured around 50 tons of butter for the year. At this stage Mr A. W. Barr was the new manager.

These difficulties were overcome and by 1916 the factory looked more prosperous with a profit of £167-20-1, indicating that the district was capable of producing milk profitably. Mr Barr, the manager, reported that the factory was making 3 tons of butter per week. Derrinallum butter commanded excellent prices in the Melbourne market and brought top prices of £208 per cwt in London

The Leader in 1916, reflected the growing optimism of the district's dairying industry:

> *The dairying industry in this part of the State has been initiated on sound lines by the erection of an up to date co-operative butter factory, conveniently situated with regard to the Derrinallum Railway station. The factory has already demonstrated its capacity to convert the farmer's cream into butter of prime quality and thereby provide a good market for it. The sale of the output of the factory is in the hands of the well known Western District Export Co-operation, whose activities in the interest of the dairy farmer can be scarcely over estimated.*
>
> (Quoted in McGregor & Oaten, 1985: 48)

After the First World War, the Soldier Settlement Commission was set up to provide farms for returned soldiers. The Larra settlement scheme, which included a portion of the Poligolet Estate, allocated 35 farms and there were also 18 settlement blocks, allocated from the Mt Elephant Estate and another seven on the Tooliarook Estate. Nearly all these farms were set up as dairy farms. There was another soldier settlement at Dundonnell (Mt Fyans) and this was also set up for dairying, and there were about 24 settlement blocks.

The progress of the factory is shown in Table 4. At its peak, the factory had around 130

Date	Value of cream (£)	Value of butter (£)	Profit/ (loss) (£)	Dividend	Directors' reports
31/8/1915	4139	5497	(61)	Nil	Very bad drought.
31/8/1916	5846	7246	167	Nil	
31/8/1917	12815	15868		Nil	More favourable climatic conditions, increased number of suppliers, favourable London market.
31/8/1918	13813	16538	622	5%	Satisfactory results, increased number of suppliers and more dairy land opening up should lead to increased supply.
31/8/1919	15351	18058	634	5%	Satisfactory results as increasing supply.
31/8/1920	19380	21924	512	5%	Business steadily increasing.
31/8/1921	32396	36424	433	Nil	
31/8/1922	25465	33131	1252	7%	
30/6/1923	28407	36237	1547	7%	Business continuing to increase. Purchase motor lorry for £796.
30/6/1924	31079	38196	(331)	7%	Good year for grazing but dry year last year cause decreased supply. Buy second lorry. Pay dividend from accumulated profit.
30/6/1925	30246	38950		7%	Urge to take care of cream on farm to ensure arrive in good condition.
30/6/1926	27145	33958	(334)	Nil	Progress of factory retarded by lack of capital and poor support of dairymen. Poor season and low London prices. Without support factory cannot hold its own and directors decide to seek buyer of factory as going concern.
9/10/1926					Resolve to sell to Holdenson & Neilson and liquidate the company. Sell for £6000. Book value £7536-17-3.

Table 4. Progress of the Derrinallum Butter Factory. *Source:* Derrinallum Cheese and Butter Factory, Directors' reports, 1915–26.

suppliers who carted their cream to the factory every second day. The majority were from the Mt Elephant and Larra closer settlement farms and a few from Vite Vite and Pura Pura. The cream from Vite Vite and Pura Pura was carried to the factory by rail. During this period, Holdenson & Nielson Fresh Food Pty Ltd, who had a butter factory at Birregurra, also operated a depot for cream at the railway station, which reduced the clientele of the butter factory. This depot was managed by Mr Anderson.

In 1918, the first dividend of 5% was paid to shareholders. Managers at the cooperative factory were George Primrose, Percy Clingin, Arthur Wilmshurst and George Elliot. In 1923, the company bought its first motor lorry for £796 and bought a second the following year. This allowed the company to exercise some control over the collection of cream and removed the necessity for farmers to deliver.

The business increased steadily until 1925 when it paid £30 246 for cream, manufactured 238 tons of butter and paid a 7% dividend. However, by 1926, problems had set in and the company recorded a £334 loss and the directors reported:

> *The progress of the Company has been retarded by lack of additional capital and insufficient support by Dairymen. The poor season and low prices in London when exports were at their highest all militated against success. The Directors are convinced that without united support the factory cannot hold its own and continue the past policy of payment and for that reason have reluctantly negotiated for the sale of the business and property as a going concern.*
>
> (Derrinallum Cheese and Butter Factory, Directors report, 1926)

On 14 September 1926, the butter factory was sold to Holdenson & Nielson Fresh Food Pty Ltd for £6000. Shareholders had voted in favour of the sale by 210 votes to 21. As well as lack of support, the decline in the industry seems to be due to a number of factors.

- The uneconomic size of the farms in the Closer Settlement scheme. Many farmers 'walked off' their farms because they were uneconomical. Farmers with larger areas were finding grazing sheep was just as profitable as dairying (and much less effort).
- In most years, the season was too short for milking cows. If there was not a good autumn (with rain), the growing days of the pasture were limited, which in turn caused the drop in the milk supply.
- Motor transport, factory and farm technology, added to the decline. With the introduction of motorised lorries, the larger factories could collect milk and cream over larger areas and put enormous pressure on the smaller factories, which did not have the economies of scale to lower costs.

Holdenson & Nielson continued to operate the factory and in 1931 began producing ice for local consumption. The quality of butter was high and obtained a silver medal for the standard of its export butter. The factory also operated a store to service the dairy farmers, selling bran, pollard, oats, groceries, clothes and boots, among other items. Mr N. Anderson resigned as the manager of the factory in 1933 and Mr George Elliott was appointed the new manager and remained until 1962.

On 23 July 1962, the factory was sold to the Camperdown–Glenormiston Dairying Co. Ltd for £14 375. They closed the factory and directed the supply to Camperdown, which now required whole milk, which was picked up by bulk milk tankers from refrigerated milk vats. After the factory closed, George Elliott's son Jack and his wife Alison bought the factory and land, and lived in one of the houses and started a piggery in the old factory. Later Jack sold the factory to Peter Janes who is the present owner.

Hence the history of the Derrinallum Butter Factory shows a small struggling factory in a marginal dairy area and eventually succumbing to the economic pressures applied by larger organisations.

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THE MOUNT

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Clive is a local farmer who has always lived in the vicinity of Mt Elephant and takes a keen interest in using local resources. He crafts garden seats and cuts fencing material from sugar gums, enjoys his work on the basalt plains, and sailing on Deep Lake. He is a member of the Country Fire Association, and is on the Mt Elephant Management Committee and the Deep Lake Reserve Committee.

THE Mount (Mt Elephant) has always been part of my life, from when I was a kid looking out of the school bus window everyday, to now when I can see the Mount from wherever I am working.

I want to reflect on the way the Mount has served the needs of the local community: from the earliest days of white settlement when it was a landmark for the first explorers, and also the travellers, who, coming from Melbourne and Geelong, had to journey north of Lake Corangamite until a route was opened up through the Stony Rises between Colac and Camperdown. Mt Elephant is now a concert venue and tourist attraction.

The earliest farmers of the district were the squatters who arrived in the late 1930s with their sheep and could claim grazing rights over as much land as they could stock. So the squatting runs were large and unfenced, and many boundary disputes erupted between these ambitious men. Hence, they used Mt Elephant as a boundary marker, and by about 1870 three properties bordered Mt Elephant: Larra, Poligolet and Mt Elephant Station. Their boundary point was a strainer post in the crater and three fences radiated out and over the sides of the mountain. Although these fences have long since gone, there is one line of stonewall running to the north-west that is a continuation of one of them and is obvious from the top of the mountain.

Later, the whole mountain was owned by the Maconochies, who owned Poligolet, and this must have pleased the men who built the fences as they could at last go around the Mount instead of over it. It was now one paddock.

In the late 1940s and 1950s, the area, like much of the Western Plains, was included in the settlement scheme for soldiers returning from WWII. This second soldier settlement scheme was set up by the government, taking into account many of the hard lessons which had been learnt by politicians and bureaucrats, following the dismal failures of many of the WWI settlement schemes. It boded well for the Second World War settlers that their blocks were large enough to support their families, and that they were able to develop viable farms.

My father, Keith May, applied for many blocks whilst he was share farming in the Lake Bolac district before being allocated a block on the Terrinallum Estate, 10 km west of Derrinallum, in 1951. There were about 60 blocks in the immediate vicinity of Derrinallum, varying in size from 400 to 800 acres, depending on their estimated carrying capacity.

When my parents first arrived on the block there was little more than one fence through the farm, and the surveyor's pegs to mark the boundary fences and house site. They brought in a bungalow Dad had built on a makeshift tractor, towed by this tractor. This bungalow, along with a galvanised iron hut, became their home until the house was built a year later.

I think that the isolation must have been the hardest part of their early days, especially for the women. There was no phone, no power, and only a rough track that wound around from one hut to the next. The track was so slow that when the neighbours were coming for tea, Mum could put on the vegetables when she saw the visiting vehicle on the track, and they would be cooked before the guests arrived. Compare that to today: with the Internet and e-mail, we can send a letter to a friend in London and get a reply more quickly that the time it takes to boil the water!

During the winter months the isolation was compounded by the lack of a road and the boggy soil conditions of the basalt plains. My parents used to hook the three-tonne truck behind the tractor and tow it across the farm, then across the neighbouring station, before reaching the Darlington Pura road, which would take them to Camperdown or Derrinallum for their shopping. The procedure was reversed on the way home.

As kids, we loved the stories of trucks, trailers and tractors being bogged in our gully, and I will relate a couple of these for you.

Dad was carting a load of fence posts, to start the improvements, on his four-wheeled trailer when it sunk in the mud and bogged the tractor. Another, bigger, tractor was brought in, and it got stuck too. So they jammed the fence posts under the tractor's wheels for traction and, by the time they finally got everything out, 20 brand new fence posts had disappeared completely into the mire and were never to be retrieved. Another time, a trailer loaded with 400 new bricks, went down in the mud on one side. Two hundred bricks were duly off-loaded with great care, but when the tractor was moved forward out of the bog, it immediately tipped to the still-loaded side. The remaining bricks were dumped into the water and mud with the rest of them.

These sorts of problems continued for three years until the road was made in 1953.

The soldier settlers went on to develop viable farms from the bare rough blocks, remembering that these areas were previously large paddocks of native vegetation which the stations ran at low stocking rates of about 3½ sheep per acre. With much hard work, and the use of fertilisers and improved clover species, the stocking rates were lifted to about four sheep to the acre.

In 1950, as the first of the settlers' blocks were being developed, Lindsay Eldridge was buying the Mount from Torchy Bristow. It was there that he started to quarry the scoria which makes up the Mount. Initially, with a pick and shovel, he loaded and sold the scoria which was to form the basis of all-seasons farm access and the hard standing areas needed for the sheds and stockyards of the productive farms. Lindsay developed his business with the introduction of mechanical loaders and, as I remember, an array of old trucks. The gravel that was carted out over the years still forms many miles of farm tracks across the basalt plains today. In those times the local community was much more dependant on local resources, whether it be water, firewood for fuel, or gravel. Now, water is piped in from the Otways, and with good roads and bigger, faster trucks, material such as gravel can be carted in quite cheaply from a fair distance. The Eldridges closed their gravel pit in 1995 and today the Corangamite Shire has the only operating pit on Mt Elephant.

The soldier settlement blocks today are mostly consolidated into larger farms of two or three of the original blocks, with the associated decline in farmer numbers. There are still many sons and daughters of the original settlers on their farms. Of the original settlers on the Terrinallum Estate, only Edna Anderson is still living on her farm; Sno and Nance Anderson have just sold their land after 50 years of farming. Sons of three of the 12 original families are still farming their blocks as a base for their larger farming operations.

Last year, when Mt Elephant was first advertised for sale, I was worried that, as the local people had always taken for granted their right of access to the Mount, that this would certainly change with a change of ownership. Many people felt that the Mount was already community-owned like the community hall: all you had to do was ask and you could go in. It was even better in some respects because the weeds and rabbits were someone else's problem. The Eldridge family had owned the Mount for 38 years and to my knowledge they had never refused access to anyone. People who wanted to drive up simply borrowed the key, and those who wanted to walk up jumped the fence. If someone else bought the Mount and paid a couple of hundred thousand for it, surely they would not want every Tom, Dick and Harry jumping their fence to walk over the new purchase? I know nothing annoys me more than finding strangers walking over my farm uninvited.

With this in mind, I joined a group of locals who felt there was an opportunity to purchase the Mount for the community. With the assistance of the Trust for Nature, who were able to purchase the Mount on our behalf, with the proviso that we raise half the purchase price, the deal was done. There is an open day on the first Sunday of every month and plans are being made for the future.

Future plans include the control of weeds and, I hope, the removal of the grazing animals. The cattle are easy to deal with: you just chase them out and shut the gate. The rabbits are more entrenched and will need a greater effort, time and money to control. In the meantime, we hope to start a little revegetation work, mark walking tracks and maintain access for everyone.

Another interesting use of the Mount in its history has been its venue for bonfires. There is quite a history of these on the Mount, beginning in 1894, when the Currie family organised a bonfire to celebrate the jubilee of their purchase of Larra in 1844.

Then, in 1919, a very large bonfire was built to mark the end of the Great War. In 1998, the local Volcanic Trail Committee organised three fires on prominent volcanic cones, including Mt Elephant, Mt Sugarloaf and Mt Noorat, to re-awaken peoples' awareness of their volcanic environment. In 1999 more fires were lit on a greater number of cones, both large and small, to mark the

approaching year 2000. Stationed on the Mount that evening, we received several visitors who drove up to be part of the action, and viewed a continuous stream of cars around the Mount, as the local people came out for a look. The publican even loaded up the drinkers from the bar and brought them out in the pub bus to be part of it.

On the first morning of 2000, a hardy bunch of about 40 people climbed the Mount in the dark to welcome the first sunrise of the year 2000. It took many glasses of champagne before the polar weather conditions moderated enough to allow us to thaw out and begin the trip down. Later, in November 2000, the first 'Music on the Mount' was enjoyed by a sell-out crowd, who listened to light opera, superb piano playing and watched the grasses rippling up the slopes in the lighting.

Mt Elephant's role in the community has changed from a simple landmark to a source of vital raw material, and now a concert venue and tourist attraction. I hope that some time in the future, when people are driving past the Mount, they will complain that they cannot see the Elephant for the trees.

LIST OF MEMBERS

Life members:

Aitken, Dr Yvonne, AM
Black, Mrs J. Hope
Bonython, Mr C. W.
Clifford, Prof. Em. H. J.
Darragh, Dr Thomas A.
Farrer, Dr K. T. H., OBE, FTSE
Finch, Dr Lance
Gordon, Mr Alan
Gunson, Dr M. M.
Knight, Mr John L.
Law, Dr Phillip G., AC, CBE, FFRSV
Lovering, Prof. John F., AO
Melouney, Mr Harald F.
Nicholls, Mr S. R. J.
Richardson, Dr Joyce R.
Rodeck, Mr Ernest, AM
Singleton, Dr O. P.
Stevens, Mr H. G., OAM
Straede, Dr W. T. S.
Straede, Mr Walter
Stubbs, Prof. Lionel L.
Talent, Dr J. A., FRSV

Corporate members:

AMRAD Corporation Ltd
Australian Centre for Psychoanalysis
Australian Delphi User Group Inc.
Davies Collison Cave
ITS Probe Analytical
Orica Ltd
Walter and Eliza Hall

Members:

Abedi, Dr Zille H.
Adams, Prof. Jerry M., FRSV
Adams, Dr Robyn B.
Agombar, Mr Stanley E.
Aitken, Mr J. K.
Allen, Mrs Joan A.
Allen, Dr Leonard R.
Allshorn, Mr Donald G.
Alsop, Mr Peter F. B.
Anderson, Dr William J.
Ansell, Ms Heather L. E.
Anthony, Ms Elizabeth
Aquilina, Mr Mark D.
Archbold, Prof. Neil W.
Ashdown, Mr Martin L.
Ashton, Assoc. Prof. David H., OAM, FFRSV
Assange, Mr Julian
Atkins, Ms Elaine V.
Attiwill, Dr Peter M.
Austin, Dr Christopher M.
Axon, Dr Paul
Ayers, Mr David J.
Ayers, Dr Gregory P.
Bacher, Mr G. J.
Badrudeen, Mr Haneef
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INCLUDING

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Birch, W. D., 1985. Calc-silicate rocks at Toolangi, Victoria. *Proceedings of the Royal Society of Victoria* 97: 1–18.

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Parsons, W. T., 1982. Weeds. In *Atlas of Victoria*, J. S. Duncan, ed., Victorian Government Printing Office, Melbourne, 122–125.

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